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ARISTOTLE

METEOROLOGICA

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WITH AN ENGLISH TRANSLATION BY

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PREFACE

THIS translation was begun shortly before the war, laid aside in 1940, and finally completed in August 1948. I have added, in proof stage, some references to publications since that date, but have not been able to use them in detail. I have acknowledged in the appropriate places help that has generously been given to me, but I should like to record here in particular my gratitude to Professor Fobes for permission to use his text and index, and my sense of indebtedness to E. W Webster's version in the Oxford Translation.

H. D. P. L.

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INTRODUCTION[a]

THE *Meteorologica* falls into two well-defined parts, Books I-III and Book IV. The first three books form a complete work by themselves. The programme set out in Book I ch 1 contains nothing that can plausibly be said to look forward to Book IV and appears to have been completed by the end of Book III,[b] and the last chapter of Book III looks forward to a treatment of metals and minerals, which Book IV does not contain. Book IV is in fact a separate treatise, as had already been noticed by the Greek commentators.[c] The two parts of the work may therefore be treated separately in this Introduction.

A. BOOKS I-III

1. *Authenticity and place.* The authenticity of these books has not been seriously questioned, and there seems no reason to doubt that they are by Aristotle.[d]

[a] I am grateful to Prof. Hackforth for reading this Introduction in manuscript and for his comments.

[b] See introductory note to Book I. ch. 1 *cf.* W. Capelle, "Das Proomium der Meteorologie," *Hermes* xlvii (1912), pp. 514-535

[c] Alex. 179. 3, Olymp. 273. 21.

[d] W. Capelle, *loc. cit*, argues cogently for the authenticity of Book I. ch 1, and, by implication, of Books I-III. *Cf.* also Ideler i pp. vi ff., St.-Hilaire pp. lxv ff.

Their place in the series of his physical works is defined in the opening chapter of Book I. There Aristotle gives, in effect, the following arrangement: (1) *The Physics*, dealing with first causes and natural movement in general; (2) the *De Caelo* i and ii, dealing with astronomy; (3) *De Caelo* iii and iv and *De Generatione et Corruptione*, dealing with the four elements, their mutual transformations and the general principles of the consequent processes of generation and destruction; (4) the *Meteorologica*; (5) the works on biology.

2. *Contents.* The subjects dealt with in Books I-III appear to us very miscellaneous. They are summarized by Aristotle in Book I. ch. 1, but can perhaps best be seen at a glance in chapter headings.

Book I.
- Ch. 1. Introduction. the place of Meteorology in the Natural Sciences and summary of matters to be dealt with.
- Chs. 2-3 Preliminaries. Ch. 2. Recapitulation of the conclusions reached on the four elements in *De Caelo* iii, iv and *De Gen. et Corr.*
- Ch. 3. The relative dispositions of air and fire in the terrestrial sphere.
- Ch. 4. Shooting stars.
- Ch. 5. The Aurora Borealis.
- Chs. 6-7. Comets.
- Ch. 8. The Milky Way.
- Ch. 9. Rain, cloud and mist.
- Ch. 10. Dew and hoar-frost.
- Ch. 11. Snow.

Ch 12. Hail.
Ch. 13. Winds, rivers and springs.
Ch. 14. Climatic changes, coast erosion and silting.

Book II. Chs. 1-3. The sea; its origin, place and saltness.
Chs. 4-6. Winds.
Chs. 7-8. Earthquakes.
Ch. 9. Thunder and lightning.

Book III. Ch. 1. Hurricanes, typhoons, firewinds and thunderbolts.
Chs. 2-3. Haloes.
Chs. 4-5. Rainbows.
Ch. 6 Rods and mock suns: concluding remarks.

It will be seen at once that we have here subjects dealt with to-day by several sciences, by astronomy, geography, geology and seismology, as well as meteorology in its modern connotation But this is typical of a stage in the development of the natural sciences in which they had not yet fully differentiated out from an all-embracing Natural Philosophy. The process of differentiation was largely started by Aristotle, and Book I. ch. 1 shows us how far he had taken it. He places the *Meteorologica*, whose subject he himself seems to feel to be somewhat ill-defined, after the *De Caelo* iii and iv and *De Gen. et Corr.* In the *De Caelo* Books I-II he deals with astronomy and cosmology. He believes the universe to be spherical in form, and accepts the system of Eudoxus which accounts for the movements of the stars and planets by a system of concentric spheres, fitting inside each other, whose combined motions produce the apparent movements of the heavenly bodies. This system of

spheres is not described in detail in the *De Caelo*, though it is apparently assumed (Book II. ch. 12, 293 a 5 ff.); the only description of it which we have is that in *Met.* Λ. ch. 8. The spheres are made of a fifth element (*cf. Meteor.* I. 2) and the innermost set of spheres is that of the moon. The region below the moon, the "terrestrial" or "sublunar" sphere, is filled by the four elements, earth, air, fire and water. They form four further concentric spheres, each element having its own natural place, but there is a constant process of intermixture between them which produces all the phenomena of the terrestrial world as we know it (*cf.* note at end of Book I. ch. 3). *De Caelo* Books III-IV outline the general doctrine of the four elements, and of their four natural places; the *De Gen. et Corr.* deals with the general principles which govern their intermixture and the consequent processes of generation and destruction which constitute the natural world. In the *Meteorologica* Aristotle comes to deal with these processes in detail. The first, and in a sense the most obvious group of them, is the meteorological group (including those astronomical phenomena which Aristotle regarded as meteorological): shooting-stars, meteors, comets and the milky way, rain, hail, snow, frost, thunder and lightning, winds of all sorts, haloes and rainbows. But though the opening words of the description in Book I. ch. 1 of the scope of the work [a] indicate that these phenomena will be its main concern, Aristotle cannot confine it within these bounds. So in Book I we have an account of rivers and springs and of coast

[a] 338 b 21 *περὶ τὸν γειτνιῶντα μάλιστα τόπον τῇ φορᾷ τῇ τῶν ἄστρων*: it is concerned with phenomena "in the region which borders most nearly on the movements of the stars."

erosion and silting, and in Book II of the sea and of earthquakes, topics which can hardly be classed as μετέωρα, though they are not unrelated to the remaining topics in these books and their inclusion is therefore not altogether surprising. But whereas Book I. ch. 1 [a] indicates that the *Meteorologica* will be followed immediately by the biological works, Book III, 378 a 15 ff., promises a treatise on metals and minerals, on the grounds that these also are products of the two exhalations studied earlier in the work.

The fact is that in the *Meteorologica* Aristotle embarks on an account of the processes of change in the four elements whose general principles have been laid down in *De Gen. et Corr.* He starts with meteorological processes and includes with them certain allied topics. But these two groups between them clearly do not exhaust the processes and products of the transformation and mixture of elements: there is a vast field of physical and chemical changes and substances left unaccounted for, and even Aristotle with his strong bias towards biology cannot have been unaware of them. Hence the promise (never fulfilled in the extant works) at the end of Book III, and hence also the inclusion of Book IV in its present position, for it is just those processes of chemical change, interpreted in terms of Aristotle's doctrine of the four elements, and certain physical properties of materials that are its subject.

B. Book IV

1. *Authenticity.* The authenticity of Book IV has

[a] 339 a 5.

been doubted, and Ross [a] says that it is " pretty certainly not genuine," while Jaeger [b] refers to it as " spurious." On the other hand, Joachim [c] treats it as genuine. The only attempt to argue the case against its authenticity is that by I. Hammer-Jensen,[d] who has in turn been criticized by Dr. V. C. B. Coutant.[e]

As Dr. Coutant remarks, H.-J.'s argument turns mainly on " an analysis of the natural philosophy behind the book " ; or, more precisely, on an attempt to show that certain ideas in the book are un-Aristotelian, for, " asserting the character of the book to be very mechanical and atomistic in its explanation of certain phenomena, she ventures to ascribe the work to Strato of Lampsacus, on the ground that Strato was the most atomistic of the Peripatetics." [f] Such arguments from the ideas expressed in a particular book and their consistency or inconsistency with the main tenets of a philosopher expressed in the main body of his work are bound to be, to some extent, subjective : but I agree with Dr. Coutant that H.-J. has failed to make a convincing case, and

[a] *Aristotle* (3rd ed.), p. 11.

[b] *Aristotle* (Eng. trans.), p. 386.

[c] *Aristotle on Coming-to-be and Passing-away* and article on " Aristotle's Conception of Chemical Combination," *J.Ph.* xxix (1903).

[d] " Das sogennante IV. Buch der Meteorologie des Aristoteles," *Hermes*, l (1915), pp. 113-136.

[e] In a dissertation for the degree of D.Ph. at Columbia University entitled *Alexander of Aphrodisias . Commentary on Book IV of Aristotle's Meteorologica*, privately printed, 1936. I am grateful to Mr. D. J. Allan of Balliol College for lending me his copy of this work (reviewed by him in *C.R.* li (Nov. 1937)), of which copies are deposited at Columbia University but which is not generally available.

[f] *Op. cit.* p. 8.

it is surprising that her arguments have remained unanswered so long.[a]

H.-J.'s two main arguments are (1) that the explanations of natural processes given in the book are of a very "mechanistic" kind, the characteristic Aristotelian insistence on the final cause being absent; (2) that the use made of the ideas of *πόροι* and *ὄγκοι* in chs. 3, 8 and 9 is un-Aristotelian and indicates a connexion with Atomism.

(1) The answer to the first of these objections is supplied by Aristotle himself in ch. 12 and overlooked by H.-J. Briefly, it is to be found in the words *τὸ γὰρ οὗ ἕνεκα ἥκιστα ἐνταῦθα δῆλον, ὅπου δὴ πλεῖστον τῆς ὕλης*" (390 a 3). "The final cause is least obvious where matter predominates." Throughout the book Aristotle is dealing with changes that arise from the mutual relations of the four "prime contraries" and the four elements through which they operate, which are the *material* basis of the universe. The formal and final causes are not entirely overlooked[b]: but, as Aristotle is careful to point out in the final chapter, they are in the nature of things less obvious when one is dealing with matter and material processes in the more elementary stages; they become obvious only when we get higher in the scale of creation, in particular when we reach plants and animals It is true[c] that in ch. 12 Aristotle speaks of the homoeomerous substances as being formed "by hot and cold and the motions set up by them" (*i.e.* by material and efficient causes only), while in *De Gen. An.* ii. 1, 734 b 29 ff. he speaks as if a final-formal cause were also

[a] W. Capelle in *Pauly-Wissowa*, Supp. Bd. vi (1935), pp. 339-342, is unconvinced by them but does not give his reasons.

[b] *Cf.* 379 b 25, 381 a 1, 388 a 20.

[c] H.-J. p. 127.

necessary for their formation But, as Dr. Coutant points out, he is not consistent elsewhere on this point in *De Gen. An* itself [a]; and what he says in ch. 12 is not that a final cause is ever entirely absent, but that in material processes of the kind dealt with in Book IV it is difficult to perceive, and can therefore, it is implied, be ignored The homoeomerous bodies are, clearly, a borderline case and can be spoken of in either way.

There is therefore nothing inconsistent with Aristotle's philosophy of nature in the comparative absence of the final-formal cause from Book IV. The subject matter is, on Aristotle's own showing, such as to make that absence likely; and it is perhaps worth adding that the same is true of the first three books, which are undoubtedly genuine, and which could with equal plausibility be argued to be "mechanical." [b] Nor is H.-J.'s contention [c] that Aristotle was hardly aware of the problems of mechanical causation and the antithesis οὗ ἕνεκα—ἐξ ἀνάγκης till they were brought to his attention by Strato as author of *Meteor.* IV in the least plausible. Aristotle was acutely aware of these problems, both in *Physics* B and in *De Part. An.* (cf. Book I. ch 1 in particular) and *De Gen. An.*; and *Physics* B and the main groundwork of his biological work were certainly completed before the end of his residence in the Troad and Lesbos.[d]

[a] 743 a 7 states the same view as *Meteor.* iv. 12 and clearly refers to it.

[b] *Cf.* Coutant, *op. cit.* p. 10.

[c] P. 126.

[d] For the *Physics cf.* the Introduction to Ross's edition. H.-J. makes no reference to the *Physics* and erroneously assumes (p 129), with Jaeger, that the biological works are late · *cf.* my paper in *C.Q.* (July-Oct. 1948). There is no

(2) H.-J. finds traces of atomistic doctrine in the references to ὄγκοι and πόροι in chs. 3, 8 and 9.[a] But there is no evidence that a belief in πόροι was characteristic of the Atomists. For if Democritus used the word in connexion with sense perception, so also did a number of other early philosophers[b]; and the use of the idea of πόροι as part of the theory of the constitution of matter is characteristic not of the atomists but of Empedocles. It is true that in *De Gen. et Corr.* i. 8 Aristotle associates the theory of "pores" with the doctrine of the Atomists on the grounds that the empty spaces between the atoms are analogous to the "pores" of Empedocles,[c] but it is clear that the two doctrines are different, that the association is made by Aristotle himself for purposes of criticism, and that the theory of pores is not part of atomist doctrine[d] The case is little better with ὄγκοι. The word is used by the Atomists and may mean "atoms," but the use is very occasional[e] and the meaning uncertain, and in Epicurus at any rate it seems to mean little more than "particle" without any specific reference to atoms[f]

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evidence that Strato attended the Lyceum during the lifetime of Aristotle. He is said to have been a pupil of Theophrastus, whom he succeeded as head of the Lyceum, dying *circa* 270–268 B C He cannot have been more than a child in the decade 350–340 B C. and can therefore hardly be responsible for having drawn Aristotle's attention to difficulties of which he was at that time well aware. *Cf.* Zeller, *Aristotle and the Earlier Peripatetics*, ii. p. 451, note 1

[a] P. 122. [b] *Cf.* Diels, *Vors.* Index, *s v.*

[c] *Cf.* 325 b 5-11.

[d] *Cf.* Joachim's notes on this chapter (*Aristotle on Coming-to-be and Passing-away*, pp. 156 ff.); and Bailey, *Greek Atomists*, chs 2 and 3.

[e] Diels, *Vors.* Index, *s v.*; Bailey, *op. cit.* p 156, note 1.

[f] Bailey, *op. cit.* pp. 577-579.

The general meaning " particle," in fact, suits the two [a] contexts in which the word occurs in Book IV very well. In both Aristotle is speaking of water penetrating and melting or softening other bodies, and it is natural enough to talk of particles of water penetrating into other materials Similarly it is not unnatural in these contexts to speak, without using the words in any technical sense, of " pores " into which the particles of water penetrate. The obvious example which presents itself is that of a sponge : and this is, in fact, used by Aristotle when speaking of pores in 386 b 5, 7 and 17. It is easy to extend the idea to penetration by fire (387 a 19, 21) and, with the analogy of the sponge in mind (386 b 5), to compressibilty (386 b 2 ff.). In all these cases the body concerned can be called " porous " without stretching the ordinary meaning of the word far. Nor need it be stretched much farther to make it cover the breaking or splitting of materials (386 a 15, 387 a 2) : the grain of wood (387 a 2), for example, is a kind of *path* (another meaning of πόρος) along which it splits [b]

The references to πόροι and ὄγκοι are thus best explained by taking the words in their non-technical ordinary meaning · and Olympiodorus' explanation [c] that by πόροι Aristotle means τὰ εὐπαθέστερα μόρια is not far wrong. There is no reason whatever to see any reference to atomism.[d] But even if the refer-

[a] 385 a 30, b 20.

[b] The passages in which πόροι are mentioned may be grouped as follows: penetration by moisture 381 b 1, 3, 385 a 29, b 20, 24, 25 ; penetration by fire 387 a 19, 21 ; compressibility 386 b 2, 4, 5, 6, 9 ; breakability 386 a 15 ; fissibility 387 a 2

[c] 313. 18.

[d] H.-J.'s case is not improved by an attempt (p. 122) to read atomism into 387 a 12 ff., where there is no conceivable reference to it.

ences to atomism were proved, this would not necessarily indicate Strato as author. For though Strato is said to have abandoned the Aristotelian teleology, to have regarded heat and cold as ultimate causes, and to have adopted the atomists' conception of the void, he is also said to have refused to accept the atomic theory itself on the grounds that the possibility of infinite division made the existence of a minimum physical body impossible.[a]

H.-J.'s two main arguments thus seem to be ill founded Without them the others can hardly carry much weight and in themselves are lacking in cogency. Most of them turn on discrepancies between statements in Book IV and statements made elsewhere by Aristotle. But as Dr. Coutant points out (p. 10, note 18), Aristotle is frequently inconsistent on minor matters ; and the search for minor inconsistencies in his works really throws little light on their authenticity. Thus if Aristotle in this book (ch. 4, 381 b 24, and 382 a 4) says that all bodies are compounded of earth and water, while in *De Gen. et Corr.* 334 b 31 ff. he says that all bodies are composed of all four elements, the difference is one of point of view rather than of fundamental doctrine. For in this book all four elements are still involved in the composition of bodies ; but two are regarded as active, and therefore as efficient cause, two as passive, and therefore as material cause. In ch. 4, 382 a 3, water is called the element most characterized by moisture, in *De*

[a] Zeller, *Phil. der Griechen* II³. 2, pp. 901 ff. : Eng. trans. *Aristotle and the Earlier Peripatetics*, pp. 456-460. H.-J.'s statement (p. 125), " Von Straton wissen wir, dass er Peripatitiker war, und doch der atomischen Lehre, die er ausbaute, seine Zustimmung gab," seems to contradict what Zeller, to whom she refers, in fact says.

Gen. et Corr 331 a 4 it is said to be characterized by cold rather than moisture but Aristotle is not consistent on this point in *De Gen et Corr.* itself and at 334 b 34 implies that water is characteristically moist, which agrees with what is said here in ch. 4.[a] Again, there is no radical inconsistency between what Aristotle says about olive oil in ch. 7, 383 b 20 ff., and what he says in *De Gen. An.* 735 b 12 ff., and I agree with Dr. Coutant that there is no conflict between what Aristotle says at 379 a 26 about ἡ οἰκεία θερμότης and what he says in Book II, 355 b 9, about the ἔμφυτος θερμότης.[b] But further detailed argument may be omitted here.

Finally, there are certain positive indications that the book is by Aristotle. There are three fairly clear references to it in the biological works (with which ch. 12 deliberately links it): *De Part. An.* ii 2, 649 a 33 ff. refers to chs. 6-8 and 10, *De Gen. An.* ii. 6, 743 a 3-7 refers to chs. 4-7, and v. 4, 784 b 8 refers to ch 1, 379 a 16. The doctrine of ch. 12 is, as has been indicated above, thoroughly Aristotelian, and indeed an important passage for Aristotle's views on teleology in organic and inorganic nature The use of the parallel between τέχνη and φύσις (*cf* ch. 2, note *a* on p 298 and ch. 3, note *b* on p 308) is typically Aristotelian, and can be found, for example, running through *Physics* B and *De Part An.* i. 1. The treatment of hard and soft as the primary qualities in chs. 4 ff is, as H.-J. herself points out (p. 120), consistent with what Aristotle says elsewhere on the subject

357 a βαδίζειν· μᾶλλον γὰρ οὕτως εὔλογον ὑπολαβεῖν ἢ διὰ ταῦτα τὸν οὐρανὸν ὅλον μεταβάλλειν.

'Αλλὰ περὶ μὲν τούτων πλείω τῆς ἀξίας ἐνδιατέτριφεν ὁ λόγος· περὶ δὲ τῆς ἁλμυρότητος, τοῖς μὲν ἅπαξ γεννήσασι καὶ ὅλως αὐτὴν γεννῶσιν ἀδύνατόν ἐστιν ἁλμυρὰν ποιεῖν. εἰ γὰρ παντὸς τοῦ ὑγροῦ τοῦ περὶ τὴν γῆν ὄντος καὶ ἀναχθέντος ὑπὸ τοῦ ἡλίου τὸ ὑπολειφθὲν ἐγένετο θάλαττα, εἶτ' ἐννυπῆρχε τοσοῦτος χυμὸς ἐν τῷ πολλῷ ὕδατι καὶ γλυκεῖ διὰ τὸ συμμειχθῆναί τινα γῆν τοιαύτην, οὐδὲν ἧττον ἐλθόντος πάλιν τοῦ διατμίσαντος ὕδατος ἀνάγκη, ἴσου γ' ὄντος τοῦ πλήθους, καὶ τὸ πρῶτον· ἢ εἰ μηδὲ τὸ πρῶτον, μηδ' ὕστερον ἁλμυρὰν αὐτὴν εἶναι. εἰ δὲ καὶ τὸ πρῶτον εὐθὺς ἦν, λεκτέον τίς ἡ αἰτία, καὶ ἅμα διὰ τί οὐκ εἰ καὶ τότε ἀνήχθη καὶ νῦν πάσχει ταὐτό. ἀλλὰ μὴν καὶ ὅσοι τὴν γῆν αἰτιῶνται τῆς ἁλμυρότητος ἐμμειγνυμένην (ἔχειν γάρ φασι πολλοὺς χυμοὺς αὐτήν, ὥσθ' ὑπὸ τῶν ποταμῶν συγκαταφερομένην διὰ τὴν μεῖξιν ποιεῖν ἁλμυράν), ἄτοπον τὸ μὴ καὶ τοὺς ποταμοὺς ἁλμυροὺς εἶναι· πῶς γὰρ δυνατὸν ἐν πολλῷ μὲν πλήθει ὕδατος ἐπίδηλον οὕτως ποιεῖν τὴν μεῖξιν τῆς τοιαύτης γῆς, ἐν ἑκάστῳ δὲ μή; δῆλον γὰρ ὅτι ἡ θάλαττά ἐστιν ἅπαν τὸ ποτάμιον ὕδωρ· οὐδενὶ

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[a] Anaxagoras (Diels 59 A 90; Aetius iii. 16. 2), Diogenes (Diels 64 A 17).

[b] Anaxagoras (Diels 59 A 90; Alex. 67. 17), Xenophanes (Diels 21 A 3 (4)), Metrodorus (Diels 70 A 19).

reasonable way of accounting for the facts than to suppose that the whole universe is in process of change.

But we have spent longer talking about these things than is really justified. To return to the sea's saltness. Those who make it come into existence all at once, or for a matter of that those who make it come into existence at all, cannot account for its saltness. For it is all the same whether they maintain (1) that sea is what is left of the moisture on the earth after evaporation by the sun,[a] or (2) that the taste inherent in the great mass of naturally sweet water is due to a suitable admixture of earth.[b] For (1) on the first view,[c] since the volume of water that falls as rain is equal to the volume evaporated, the sea must either have been salt in the first place, or if it was not it cannot have become salt subsequently. But if it was salt at first the reason for this should be given, and also the reason why if salt water was subject to evaporation then it is not now. While (2) as for those who attribute the sea's saltness to an admixture of earth, saying that the earth has many tastes and so when carried down by the rivers and mixed with the sea it makes it salt—if that is so it is odd that the rivers are not salt also. For how is it possible that the admixture of earth of this kind should have so obvious an effect in a large volume of water, but not in each individual river? For it is clear that on this view the sea is composed of water from the rivers, as it does not differ from the rivers

The sea's saltness: three views dismissed.

[c] Thurot points out that the clause beginning *οὐδὲν ἧττον* deals only with the first of the two views put forward in the previous sentence, and that the passage makes better sense if it is supposed that some words have dropped out after *τοιαύτην*. But neither MSS. nor commentators give any indication of a lacuna.

357 a γὰρ διέφερεν ἀλλ' ἢ τῷ ἁλμυρὰ εἶναι τῶν ποταμῶν· τοῦτο δ' ἐν ἐκείνοις ἔρχεται εἰς τὸν τόπον εἰς ὃν ἀθρόοι ῥέουσιν.

25 Ὁμοίως δὲ γελοῖον κἂν εἴ τις εἰπὼν ἱδρῶτα τῆς γῆς εἶναι τὴν θάλατταν οἴεταί τι σαφὲς εἰρηκέναι, καθάπερ Ἐμπεδοκλῆς· πρὸς ποίησιν μὲν γὰρ οὕτως εἰπὼν ἴσως εἴρηκεν ἱκανῶς (ἡ γὰρ μεταφορὰ ποιητικόν), πρὸς δὲ τὸ γνῶναι τὴν φύσιν οὐχ ἱκανῶς· οὐδὲ γὰρ ἐνταῦθα δῆλον πῶς ἐκ γλυκέος τοῦ

30 πόματος ἁλμυρὸς γίγνεται ὁ ἱδρώς, πότερον ἀπελθόντος τινὸς μόνον οἷον τοῦ γλυκυτάτου, ἢ συμμειχθέντος τινός, καθάπερ ἐν τοῖς διὰ τῆς τέφρας ἠθουμένοις ὕδασιν. φαίνεται δὲ τὸ αἴτιον ταὐτὸ καὶ περὶ τὸ εἰς τὴν κύστιν περίττωμα συλλεγόμενον· καὶ γὰρ ἐκεῖνο πικρὸν καὶ ἁλμυρὸν γίγνεται τοῦ

357 b πινομένου καὶ τοῦ ἐν τῇ τροφῇ ὑγροῦ γλυκέος ὄντος. εἰ δὴ ὥσπερ τὸ διὰ τῆς κονίας ἠθούμενον ὕδωρ γίγνεται πικρόν, καὶ ταῦτα, τῷ μὲν οὔρῳ συγκαταφερομένης τοιαύτης τινὸς δυνάμεως οἵα καὶ φαίνεται ὑφισταμένη ἐν τοῖς ἀγγείοις ἁλμυρίς,

5 τῷ δ' ἱδρῶτι συνεκκρινομένης ἐκ τῶν σαρκῶν, οἷον καταπλύνοντος τὸ τοιοῦτον ἐκ τοῦ σώματος τοῦ ἐξιόντος ὑγροῦ, δῆλον ὅτι κἂν τῇ θαλάττῃ τὸ ἐκ τῆς γῆς συγκαταμισγόμενον τῷ ὑγρῷ αἴτιον τῆς ἁλμυρότητος. ἐν μὲν οὖν τῷ σώματι γίγνεται τὸ τοιοῦτον ἡ τῆς τροφῆς ὑπόστασις διὰ τὴν ἀπεψίαν·

10 ἐν δὲ τῇ γῇ τίνα τρόπον ὑπῆρχε, λεκτέον. ὅλως δὲ πῶς οἷόν τε τοσοῦτον ὕδατος πλῆθος ξηραινομένης καὶ θερμαινομένης ἐκκριθῆναι; πολλοστὸν γὰρ δεῖ μέρος αὐτὸ τοῦ λειφθέντος εἶναι ἐν τῇ γῇ. ἔτι διὰ τί οὐ καὶ νῦν ὅταν ξηραινομένη τύχῃ γῆ, εἴτε πλείων εἴτε ἐλάττων, ἱδίει; †ἡ γὰρ ὑγρότης

except in being salt and the salt is carried down in them to the place into which they all flow.

It is equally absurd (3) for anyone to think, like Empedocles,[a] that he has made an intelligible statement when he says that the sea is the sweat of the earth. Such a statement is perhaps satisfactory in poetry, for metaphor is a poetic device, but it does not advance our knowledge of nature. For it is by no means clear how salt sweat is produced in the body from sweet drink—whether, for example, it is simply by the loss of its sweetest constituent or whether it is due to the admixture of something else, as in the case of waters strained through ashes. The cause appears to be the same as that which makes the residue that collects in the bladder bitter and salty though our drink and the liquid in our food is sweet. If then the cause in both cases is the same as that which makes water filtered through ashes bitter, and if some substance like the salty deposit we see in chamber-pots is carried through the body with the urine, and secreted in sweat from the flesh, being washed out of the body as it were by the water on its way out, then the admixture of some substance from the earth must be responsible for the saltness of the water in the sea also. Now in the body the sediment of food caused by failure to digest is such a substance. But we still need to be told how anything of the kind is produced in the earth. Besides, more generally, how can the drying and heating of the earth cause the secretion of so large a volume of water? And this can only be a small proportion of what is still left in the earth. Again, why does not the earth still sweat to-day when dried in larger or smaller quantities? [For sweat and

[a] Diels 31 A 66.

357 b
καὶ ὁ ἁλὸς γίγνεται πικρός.†[1] εἴπερ γὰρ καὶ τότε, καὶ νῦν ἐχρῆν. οὐ φαίνεται δὲ τοῦτο συμβαῖνον, ἀλλὰ ξηρὰ μὲν οὖσα ὑγραίνεται, ὑγρὰ δ' οὖσα οὐδὲν πάσχει τοιοῦτον. πῶς οὖν οἷόν τε περὶ τὴν πρώτην γένεσιν, ὑγρᾶς οὔσης τῆς γῆς, ἁλίειν ξηραινομένην; ἀλλὰ μᾶλλον εἰκός, ὥσπερ φασί τινες, ἀπελθόντος τοῦ πλείστου καὶ μετεωρισθέντος τοῦ ὑγροῦ διὰ τὸν ἥλιον, τὸ λειφθὲν εἶναι θάλατταν· ὑγρὰν δ' οὖσαν ἁλίειν ἀδύνατον.

Τὰ μὲν οὖν λεγόμενα τῆς ἁλμυρότητος αἴτια διαφεύγειν φαίνεται τὸν λόγον· ἡμεῖς δὲ λέγωμεν ἀρχὴν λαβόντες τὴν αὐτὴν ἣν καὶ πρότερον.

Ἐπειδὴ γὰρ κεῖται διπλῆν εἶναι τὴν ἀναθυμίασιν, τὴν μὲν ὑγρὰν τὴν δὲ ξηράν, δῆλον ὅτι ταύτην οἰητέον ἀρχὴν εἶναι τῶν τοιούτων.

Καὶ δὴ καὶ περὶ οὗ ἀπορῆσαι πρότερον ἀναγκαῖον, πότερον καὶ ἡ θάλαττα ἀεὶ διαμένει τῶν αὐτῶν οὖσα μορίων ἀριθμῷ ἢ τῷ εἴδει καὶ τῷ ποσῷ μεταβαλλόντων ἀεὶ τῶν μερῶν, καθάπερ ἀὴρ καὶ τὸ πότιμον ὕδωρ καὶ πῦρ (ἀεὶ γὰρ ἄλλο καὶ ἄλλο γίγνεται τούτων ἕκαστον, τὸ δ' εἶδος τοῦ πλήθους ἑκάστου τούτων μένει, καθάπερ τὸ τῶν ῥεόντων ὑδάτων καὶ τὸ τῆς φλογὸς ῥεῦμα)· φανερὸν δὴ καὶ τοῦτο καὶ πιθανόν, ὡς ἀδύνατον μὴ τὸν αὐτὸν εἶναι περὶ πάντων τούτων λόγον, καὶ διαφέρειν ταχυτῆτι καὶ βραδυτῆτι τῆς μεταβολῆς, ἐπὶ

[1] ἡ γὰρ ὑγρότης om. 𝔄 H_1 N_1 Thurot: ἡ . . . πικρός om. O.T.

[a] These words do not fit into the argument. "The point is not that the earth secretes moisture but not salt moisture; but, as the following lines show, that it does not secrete any-

moisture are both bitter.][a] For if it used to happen once it should happen now. Yet in fact it does not happen, but when earth is dry it absorbs moisture, when it is moist it shows no sign of sweating. How then can the earth when it first came into being and was moist have sweated when dried? The view that most of the moisture left it and was drawn aloft by the sun and that the sea is what was left is more plausible. But it cannot possibly sweat when it is moist.

Thus none of the current explanations of the sea's saltness appear to stand examination, so let us offer our own, starting from the principle already laid down.

Saltness due to the dry exhalation.

We have assumed that there are two kinds of exhalation, one moist and one dry; and of these the latter must clearly be the origin of the phenomena in question.

But there is a difficulty which we must discuss first. Does the sea always consist of identically the same parts; or does it remain the same in quality and quantity though the parts are continually changing, as in air, fresh water and fire? For each of these is in constant process of change, though the characteristic qualities of any aggregate of it remain the same, as for instance with running water and a burning flame. It is then obviously plausible to assume that the same account must hold good of all of them, so that they differ only in that their speed of change

thing at all under the conditions supposed" (O.T.). The O.T. omits the words altogether: but if the passage is to be emended it seems better to follow Thurot and to omit *ἡ γὰρ ὑγρότης* and read *ἰδίει, καὶ ὁ ἱδρὼς γίγνεται πικρός;* "Why does not the earth still sweat . . . and that sweat taste salt?"

358 a

πάντων τε φθορὰν εἶναι καὶ γένεσιν, ταύτην μέντοι τεταγμένως συμβαίνειν πᾶσιν αὐτοῖς.

Τούτων δ' οὕτως ἐχόντων, πειρατέον ἀποδοῦναι τὴν αἰτίαν καὶ περὶ τῆς ἁλμυρότητος. φανερὸν δὴ διὰ πολλῶν σημείων ὅτι γίγνεται τοιοῦτος ὁ χυμὸς διὰ σύμμειξίν τινος. ἔν τε γὰρ τοῖς σώμασι τὸ ἀπεπτότατον ἁλμυρὸν καὶ πικρόν, ὥσπερ καὶ πρότερον εἴπομεν· ἀπεπτότατον γὰρ τὸ περίττωμα τῆς ὑγρᾶς τροφῆς· τοιαύτη δὲ πᾶσα μὲν ἡ ὑπόστασις, μάλιστα δὲ ἡ εἰς τὴν κύστιν (σημεῖον δ' ὅτι λεπτοτάτη ἐστίν· τὰ δὲ πεττόμενα πάντα συνίστασθαι πέφυκεν)· ἔπειτα ἱδρώς [ἀεί][1]· ἐν οἷς τὸ αὐτὸ σῶμα συνεκκρίνεται, ὃ ποιεῖ τὸν χυμὸν τοῦτον. ὁμοίως δὲ καὶ ἐν τοῖς καομένοις· οὐ γὰρ ἂν μὴ κρατήσῃ τὸ θερμόν, ἐν μὲν τοῖς σώμασι γίγνεται περίττωσις, ἐν δὲ τοῖς καομένοις τέφρα. διὸ καὶ τὴν θάλατταν τινες ἐκ κατακεκαυμένης φασὶ γενέσθαι γῆς. ὃ οὕτω μὲν εἰπεῖν ἄτοπον, τὸ μέντοι ἐκ τοιαύτης ἀληθές· ὥσπερ γὰρ καὶ ἐν τοῖς εἰρημένοις, οὕτω καὶ ἐν τῷ ὅλῳ ἔκ τε τῶν φυομένων καὶ γιγνομένων κατὰ φύσιν ἀεὶ δεῖ νοεῖν, ὥσπερ ἐκ πεπυρωμένων τὸ λειπόμενον τοιαύτην εἶναι γῆν, καὶ δὴ καὶ τὴν ἐν τῇ ξηρᾷ ἀναθυμίασιν πᾶσαν· αὕτη γὰρ καὶ παρέχεται τὸ πολὺ τοῦτο πλῆθος. μεμειγμένης δ' οὔσης, ὥσπερ εἴπομεν, τῆς τε ἀτμιδώδους ἀναθυμιάσεως καὶ τῆς ξηρᾶς, ὅταν συνιστῆται εἰς νέφη καὶ ὕδωρ, ἀναγκαῖον ἐμπεριλαμβάνεσθαί τι πλῆθος ἀεὶ ταύτης τῆς δυνάμεως, καὶ συγκατα-
φέρεσθαι πάλιν ὄντος, καὶ τοῦτ' ἀεὶ γίγνεσθαι

differs. In all the process of decay and generation is taking place, though in all it takes place in a fixed manner.

This being so, let us try and give the reason for the sea's saltness. There are many indications that this kind of salty taste is due to the admixture of something. For in living bodies it is the least digested matter that is salty and bitter, as we have remarked before. For the residue of liquid food is least digested; this is true of all waste products, principally of that which collects in the bladder (whose extreme lightness proves it to be a waste product, as digestion naturally condenses), but also of sweat. In both of these the same substance is secreted and produces this taste. Something similar happens in combustion. What the heat fails to master becomes residue in living bodies, ash in combustion. So some have maintained that the sea is made of burnt earth. Thus expressed their opinion is absurd: but it is true that something of this sort makes it salt. For we must suppose that something happens in the world as a whole analogous to what happens in the phenomena just described: just as in combustion there is a residue of earth of this kind, so there is in all natural growth and generation, and all exhalation on dry land is such a residue. And it is dry land that provides the great bulk of the exhalation. Now since, as we have said, the moist and vaporous exhalation is mixed with the dry, when it condenses into clouds and rain it must necessarily include a certain amount of this property [a] which will subsequently be carried down in rain. The process follows a regular order,

[a] *i.e.* the dry exhalation which being a residue is salty.

[1] secl. Fobes.

358 a κατά τινα τάξιν, ὡς ἐνδέχεται μετέχειν τὰ ἐνταῦθα τάξεως. ὅθεν μὲν οὖν ἡ γένεσις ἔνεστιν τοῦ ἁλμυροῦ ἐν τῷ ὕδατι, εἴρηται.

Καὶ διὰ τοῦτο τά τε νότια ὕδατα πλατύτερα καὶ τὰ πρῶτα τῶν μετοπωρινῶν· ὅ τε γὰρ νότος καὶ 30 τῷ μεγέθει καὶ τῷ πνεύματι[1] ἀλεεινότατος ἄνεμός ἐστιν, καὶ πνεῖ ἀπὸ τόπων ξηρῶν καὶ θερμῶν, ὥστε μετ' ὀλίγης ἀτμίδος. διὸ καὶ θερμός ἐστιν· εἰ γὰρ καὶ μὴ τοιοῦτος, ἀλλ' ὅθεν ἄρχεται πνεῖν ψυχρός, οὐδὲν ἧττον προϊὼν διὰ τὸ συμπεριλαμβάνειν πολλὴν ἀναθυμίασιν ξηρὰν ἐκ τῶν σύνεγγυς τόπων 35 θερμός ἐστιν· ὁ δὲ βορέας ἅτε ἀφ' ὑγρῶν τόπων 358 b ἀτμιδώδης· διὸ ψυχρός· τῷ δ' ἀπωθεῖν αἴθριος ἐνταῦθα, ἐν δὲ τοῖς ἐναντίοις ὑδατώδης. ὁμοίως δὲ καὶ ὁ νότος αἴθριος τοῖς περὶ τὴν Λιβύην. πολὺ οὖν ἐν τῷ καταφερομένῳ ὕδατι συμβάλλεται τοιοῦτον, καὶ τοῦ μετοπώρου πλατέα τὰ ὕδατα· ἀνάγκη 5 γὰρ τὰ βαρύτατα πρῶτα φέρεσθαι. ὥστ' ἐν ὅσοις ἔνεστι τῆς τοιαύτης γῆς πλῆθος, ῥέπει τάχιστα κάτω ταῦτα. καὶ θερμή γε ἡ θάλαττα διὰ τοῦτό ἐστιν· πάντα γὰρ ὅσα πεπύρωται, ἔχει δυνάμει θερμότητα ἐν αὑτοῖς. ὁρᾶν δ' ἔξεστι καὶ τὴν κονίαν καὶ τὴν τέφραν καὶ τὴν ὑπόστασιν τῶν ζῴων 10 καὶ τὴν ξηρὰν καὶ τὴν ὑγράν· καὶ τῶν θερμοτάτων γε κατὰ τὴν κοιλίαν ζῴων συμβαίνει θερμοτάτην εἶναι τὴν ὑπόστασιν.

Γίγνεται μὲν οὖν ἀεί τε πλατυτέρα διὰ ταύτην τὴν αἰτίαν, ἀνάγεται δ' ἀεί τι μέρος αὐτῆς μετὰ τοῦ γλυκέος (ἀλλ' ἔλαττον τοσούτῳ ὅσῳ καὶ ἐν τῷ

[1] καὶ τῷ μεγέθει καὶ τῷ πνεύματι om. O.T.

so far as things in this world admit of regularity. This then accounts for the presence of salt in sea water.

Southerly rains and autumn rains brackish

This explains why the rains from the south and the first rains of autumn are brackish For the south wind is the warmest of winds (both in size and strength [a]) and blows from regions that are dry and warm, and so contains little moist exhalation, which is the reason why it is hot. And even if it is not naturally hot but starts as a cold wind, it none the less becomes hot because it picks up large quantities of hot exhalation from the places that lie on its way. The north wind, on the other hand, carries moist vapour because it comes from damp places. So it is also cold. And it brings fine weather here because it drives the clouds away ; but in the south it brings rain. Similarly the south wind brings fine weather in Libya. There is then a great deal of this substance in the rain which falls ; and the rains of autumn are brackish because what is heaviest must fall first and so rain which contains any quantity of earth of this sort falls quickest. And this is the reason why the sea is warm. For everything which has been exposed to fire contains heat potentially. We can see this in ash, in cinders and in the excrement of animals, both solid and liquid. For the excrement of animals that have the hottest bellies is hottest.

Salt is left by evaporation.

This cause is always operating to make the sea more brackish. A certain amount of the salt water is always drawn up with the sweet, but this amount is always the less in the same proportion as the salt

[a] It is difficult to make sense of these words, which the O.T. omits. Alex. (84. 32) does not appear to have had them in his text.

and brackish element is less than the sweet in rain water, so that on the whole equality is preserved.[a] I have proved by experiment that salt water evaporated forms fresh and the vapour does not when it condenses condense into sea water again. The same is true in other cases. For wine [b] and all other tasting liquids which can be evaporated and subsequently condensed to liquid again become water on condensation. For the qualities they have other than those of water are due to admixture, and the taste varies according to what is mixed with the water. But we must investigate these subjects on another and more suitable opportunity. For the present let us confine ourselves to saying that a certain amount of the existing sea water is always being drawn up and becoming fresh; and that it subsequently falls down in rain in a different form [c] to that in which it was drawn up, and because of its weight sinks below the fresh water. So the sea like the rivers never dries up, except locally (as both sea and rivers alike must on occasion); nor do the same parts always remain sea, the same land, though the whole bulk of each remains constant (for we must suppose that the same thing is true of land as of the sea). For part of the sea rises up, part of it falls again, and both that which rises and that which falls change their positions.[d]

Saltness an admixture: Examples.

That saltness consists in an admixture is evident

[c] Because of the inclusion of dry exhalation, 358 a 33.

[d] *Cf.* 358 b 25-27: it seems to make better sense to take τὸ μέν . . . τὸ δέ, ll. 31-32, as meaning the water of the sea and as referring to 358 b 25-27, with Saint-Hilaire, than to take them with the preceding sentence καὶ γάρ . . . ὑπολαβεῖν with the O.T. I have repunctuated Fobes' text accordingly. Ideler i. p. 83 punctuates as Fobes does, but translates in the same sense as Saint-Hilaire.

358 b
35 οὐ μόνον ἐκ τῶν εἰρημένων, ἀλλὰ καὶ ἐάν τις
359 a ἀγγεῖον πλάσας θῇ κήρινον εἰς τὴν θάλατταν, περι-
δήσας τὸ στόμα τοιούτοις ὥστε μὴ παρεγχεῖσθαι
τῆς θαλάττης· τὸ γὰρ εἰσιὸν διὰ τῶν τοίχων τῶν
κηρίνων γίγνεται πότιμον ὕδωρ· ὥσπερ γὰρ δι'
ἠθμοῦ τὸ γεῶδες ἀποκρίνεται καὶ τὸ ποιοῦν τὴν
5 ἁλμυρότητα διὰ τὴν σύμμειξιν. τοῦτο γὰρ αἴτιον
καὶ τοῦ βάρους (πλέον γὰρ ἕλκει τὸ ἁλμυρὸν ἢ τὸ
πότιμον) καὶ τοῦ πάχους· καὶ γὰρ τὸ πάχος δια-
φέρει τοσοῦτον ὥστε τὰ πλοῖα ἀπὸ τοῦ αὐτοῦ τῶν
ἀγωγίμων βάρους ἐν μὲν τοῖς ποταμοῖς ὀλίγου
10 καταδύνειν, ἐν δὲ τῇ θαλάττῃ μετρίως ἔχειν καὶ
πλευστικῶς· διόπερ ἔνιοι τῶν ἐν τοῖς ποταμοῖς
γεμιζόντων διὰ ταύτην τὴν ἄγνοιαν ἐζημιώθησαν.
τεκμήριον δὲ τοῦ μειγνυμένου τὸ παχύτερον εἶναι
τὸν ὄγκον· ἐὰν γάρ τις ὕδωρ ἁλμυρὸν ποιήσῃ
σφόδρα μείξας ἅλας, ἐπιπλέουσι τὰ ᾠά, κἂν ᾖ
15 πλήρη· σχεδὸν γὰρ ὥσπερ πηλὸς γίγνεται· τοσοῦτον
ἔχει σωματῶδες πλῆθος ἡ θάλαττα. ταὐτὸ δὲ τοῦτο
δρῶσι καὶ περὶ τὰς ταριχείας.

Εἰ δ' ἔστιν ὥσπερ μυθολογοῦσί τινες ἐν Παλαι-
στίνῃ τοιαύτη λίμνη, εἰς ἣν ἐάν τις ἐμβάλῃ συνδήσας
ἄνθρωπον ἢ ὑποζύγιον ἐπιπλεῖν καὶ οὐ καταδύεσθαι
20 κατὰ τοῦ ὕδατος, μαρτύριον ἂν εἴη τι τοῖς εἰρη-
μένοις· λέγουσι γὰρ πικρὰν οὕτως εἶναι τὴν λίμνην
καὶ ἁλμυρὰν ὥστε μηδένα ἰχθὺν ἐγγίγνεσθαι, τὰ

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[a] *Cf. Hist An.* viii. 2. 2, 590 a 24. As the O.T. notes, facts do not bear out Aristotle's statement, which makes it appear that he has not tried the experiment, but was taking it on hearsay. Pliny xxi. 37 and Aelian ix. 64 repeat Aris-

not only from what has now been said but also from the following experiment. Make a jar of wax and put it into the sea, having fastened its mouth in such a way as to prevent the sea getting in. It will be found that the water which gets through the wax walls is fresh, for the earthy substance whose admixture caused the saltness is separated off as though by a filter.[a] This substance is also the cause of its weight (for salt water weighs more than fresh) and of its density. For there is so great a difference in density between salt and fresh water that vessels laden with cargoes of the same weight almost sink in rivers, but ride quite easily at sea and are quite seaworthy And an ignorance of this has sometimes cost people dear who load their ships in rivers. The following is a proof that the density of a fluid is greater when a substance is mixed with it. If you make water very salt by mixing salt in with it eggs will float on it, even when unblown, for the water becomes like mud. The sea contains a like quantity of earthy substance. The same thing is done in salting fish.[b]

If there were any truth in the stories they tell about the lake in Palestine[c] it would further bear out what I say. For they say if you bind a man or beast and throw him into it he floats and does not sink beneath the surface; and that the lake is so bitter and salty that there are no fish in it, and that if you

totle's statement. κεράμινον ("earthenware") has been conjectured for κήρινον (*cf.* O.T. note on *Hist. An. loc. cit.*): but there is no MS. support for this and Pliny and Aelian have "wax."

[b] Alex (88. 5) connects this with the statement about eggs, saying that the salt solution in which fish were salted was tested by floating an egg in it: when the egg floated the solution was strong enough.

[c] The Dead Sea.

359 a δὲ ἱμάτια ῥύπτειν, ἐάν τις διασείσῃ βρέξας. ἔστι δὲ καὶ τὰ τοιαῦτα σημεῖα πάντα τῶν εἰρημένων, ὅτι τὸ ἁλμυρὸν ποιεῖ σῶμά τι, καὶ γεῶδές ἐστιν
25 τὸ ἐνυπάρχον· ἔν τε γὰρ τῇ Χαονίᾳ κρήνη τίς ἐστιν ὕδατος πλατυτέρου, ἀπορρεῖ δ' αὕτη εἰς ποταμὸν πλησίον γλυκὺν μέν, ἰχθῦς δ' οὐκ ἔχοντα· εἴλοντο γὰρ δή, ὡς οἱ ἐκεῖ μυθολογοῦσιν, ἐξουσίας δοθείσης ὑπὸ τοῦ Ἡρακλέους, ὅτ' ἦλθεν ἄγων ἐκ τῆς Ἐρυθείας τὰς βοῦς, ἅλας ἀντὶ τῶν ἰχθύων, οἳ γίγνονται
30 αὐτοῖς ἐκ τῆς κρήνης· τούτου γὰρ τοῦ ὕδατος ἀφέψοντές τι μέρος τιθέασι, καὶ γίγνεται ψυχθέν, ὅταν ἀπατμίσῃ τὸ ὑγρὸν ἅμα τῷ θερμῷ, ἅλες, οὐ χονδροὶ ἀλλὰ χαῦνοι καὶ λεπτοὶ ὥσπερ χιών. εἰσίν τε τήν τε δύναμιν ἀσθενέστεροι τῶν ἄλλων καὶ πλείους ἡδύνουσιν ἐμβληθέντες, καὶ τὴν χροιὰν
35 οὐχ ὁμοίως λευκοί. τοιοῦτον δ' ἕτερον γίγνεται
359 b καὶ ἐν Ὀμβρικοῖς· ἔστι γάρ τις τόπος ἐν ᾧ πεφύκασι κάλαμοι καὶ σχοῖνος· τούτων κατακάουσι, καὶ τὴν τέφραν ἐμβάλλοντες εἰς ὕδωρ ἀφέψουσιν· ὅταν δὲ λίπωσί τι μέρος τοῦ ὕδατος, τοῦτο ψυχθὲν ἁλῶν γίγνεται πλῆθος.

5 Ὅσα δ' ἐστὶν ἁλμυρὰ ῥεύματα ποταμῶν ἢ κρηνῶν, τὰ πλεῖστα θερμά ποτε εἶναι δεῖ νομίζειν, εἶτα τὴν μὲν ἀρχὴν ἀπεσβέσθαι τοῦ πυρός, δι' ἧς δὲ διηθοῦνται γῆς, ἔτι μένειν οὖσαν οἷον κονίαν καὶ τέφραν. εἰσὶ δὲ πολλαχοῦ καὶ κρῆναι καὶ ῥεύματα ποταμῶν παντοδαπὸς ἔχοντα χυμούς, ὧν πάντων
10 αἰτιατέον τὴν ἐνοῦσαν ἢ ἐγγιγνομένην[1] δύναμιν πυρός· καομένη γὰρ ἡ γῆ τῷ μᾶλλον καὶ ἧττον παντοδαπὰς λαμβάνει μορφὰς καὶ χρόας χυμῶν· στυπτηρίας γὰρ καὶ κονίας καὶ τῶν ἄλλων τῶν τοιούτων γίγνεται πλήρης δυνάμεων, δι' ὧν τὰ

wet clothes in it and shake them out it cleans them. The following facts also all support our contention that it is the presence of a substance that makes water salt, and that the substance present is earthy. In Chaonia there is a spring of brackish water which flows into a neighbouring river that is sweet but contains no fish. For the inhabitants have a story that when Heracles, on his way through with the oxen from Erytheia, gave them the choice, they chose to get salt instead of fish from the spring. For they boil off some water from it and let the rest stand; and when it has cooled and the moisture has evaporated with the heat salt is left, not in lumps but in a loose powder like snow. It is also rather weaker than other salt and more of it must be used for seasoning, nor is it quite so white. Something of a similar sort happens also in Umbria. There is a place there where reeds and rushes grow: these they burn and throw their ashes into water and boil it till there is only a little left, and this when allowed to cool produces quite a quantity of salt.

Most salt rivers and springs must be considered to have once been hot; subsequently the fiery principle in them was extinguished, but the earth through which they filter retains qualities like those of ash and cinders. And there are in various places many springs and streams with many different tastes, the cause of which is always a fiery element inherent or produced in them. For the earth when subject to combustion takes on to a greater or lesser degree all kinds and shades of taste. For it becomes full of alum and ash and substances of like qualities, and sweet

[1] ἐγγενομένην J O.T.

359 b ἠθούμενα ὕδατα ὄντα γλυκέα μεταβάλλει, καὶ τὰ
15 μὲν ὀξέα γίγνεται, καθάπερ ἐν τῇ Σικάνῃ τῆς Σικελίας· ἐκεῖ γὰρ ὀξάλμη γίγνεται, καὶ χρῶνται καθάπερ ὄξει πρὸς ἔνια τῶν ἐδεσμάτων αὐτῷ. ἔστι δὲ καὶ περὶ Λύγκον κρήνη τις ὕδατος ὀξέος, περὶ δὲ τὴν Σκυθικὴν πικρά· τὸ δ' ἀπορρέον αὐτῆς τὸν ποταμὸν εἰς ὃν εἰσβάλλει ποιεῖ πικρὸν ὅλον.
20 αἱ δὲ διαφοραὶ τούτων ἐκεῖθεν δῆλαι, ποῖοι χυμοὶ ἐκ ποίων γίγνονται κράσεων· εἴρηται δὲ περὶ αὐτῶν χωρὶς ἐν ἄλλοις.

Περὶ μὲν οὖν ὕδατος καὶ θαλάττης, δι' ἃς αἰτίας αἰεί τε συνεχῶς εἰσι καὶ πῶς μεταβάλλουσι καὶ τίς ἡ φύσις αὐτῶν, ἔτι δ' ὅσα πάθη κατὰ φύσιν αὐτοῖς
25 συμβαίνει ποιεῖν ἢ πάσχειν, εἴρηται σχεδὸν ἡμῖν περὶ τῶν πλείστων.

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[a] *Cf.* Eichholz in *C.Q.* xliii (July-Oct. 1949), p. 145 on this passage.

CHAPTER IV

ARGUMENT

The causes of winds. There are, as we have said, two kinds of exhalation from the earth, dry and moist. These are caused by the sun, whose movement in the ecliptic gives rise to seasonal changes. The moist exhalation produces rain, the dry exhalation wind (359 b 27—360 a 17). *So rain and wind differ in substance : and we cannot regard wind as air in motion* (360 a 17-21, 27-33). *Air then is made up of two exhalations, one moist and cold, one hot and dry, and is itself in consequence moist and hot. The predominance of one or*

b 27 Περὶ δὲ πνευμάτων λέγωμεν, λαβόντες ἀρχὴν τὴν εἰρημένην ἡμῖν ἤδη πρότερον. ἔστι γὰρ δύ' εἴδη

water changes when filtered through them.[a] Sometimes it becomes acid, as in Sicania in Sicily: for there it becomes both salt and acid and they use it as vinegar on some of their dishes And there is an acid spring also at Lyncus, and a bitter one in Scythia the water from which makes the whole river into which it flows bitter.[b] These differences are clear from a knowledge of the different tastes produced by different mixtures, a subject which has been dealt with separately elsewhere.[c]

We have now dealt with the causes of the continued existence of water and the sea and of their changes, with their nature, and with most of their various natural characteristics active and passive.

[b] *Cf.* Herod. iv. 52, 81.
[c] *De Sensu*, ch. 4; or a lost work.

CHAPTER IV

ARGUMENT (*continued*)

other exhalation accounts for variations in rainfall from year to year (360 a 21-27, 33–b 26). *Why wind occurs after rainfall, rainfall when wind drops* (360 b 26—361 a 4). *Why the prevailing winds are northerly or southerly* (361 a 4-22). *Winds originate from the earth (as exhalation), but their movement is determined by that of the celestial region. The exhalation of which they are composed collects gradually* (361 a 22–b 8).

(*With chs.* 4-6 cf. Problems *xxvi.*)

Two kinds of exhalation. wind

LET us now give an account of winds, on the lines we have already laid down. For we have said[a] that there

[a] *Cf.* Book I. ch. 4, 341 b 6 ff.

359 b τῆς ἀναθυμιάσεως, ὥς φαμεν, ἡ μὲν ὑγρὰ ἡ δὲ
30 ξηρά· καλεῖται δ' ἡ μὲν ἀτμίς, ἡ δὲ τὸ μὲν ὅλον
ἀνώνυμος, τῷ δ' ἐπὶ μέρους ἀνάγκη χρωμένους
καθόλου προσαγορεύειν αὐτὴν οἷον καπνόν· ἔστι
δ' οὔτε τὸ ὑγρὸν ἄνευ τοῦ ξηροῦ οὔτε τὸ ξηρὸν
ἄνευ τοῦ ὑγροῦ, ἀλλὰ πάντα ταῦτα λέγεται κατὰ
τὴν ὑπεροχήν.

Φερομένου δὴ τοῦ ἡλίου κύκλῳ, καὶ ὅταν μὲν
35 πλησιάζῃ, τῇ θερμότητι ἀνάγοντος τὸ ὑγρόν, πορ-
360 a ρωτέρω δὲ γιγνομένου διὰ τὴν ψύξιν συνισταμένης
πάλιν τῆς ἀναχθείσης ἀτμίδος εἰς ὕδωρ (διὸ χει-
μῶνός τε μᾶλλον γίγνεται τὰ ὕδατα, καὶ νύκτωρ
ἢ μεθ' ἡμέραν· ἀλλ' οὐ δοκεῖ, διὰ τὸ λανθάνειν τὰ
5 νυκτερινὰ τῶν μεθ' ἡμέραν μᾶλλον), τὸ δὴ κατιὸν
ὕδωρ διαδίδοται πᾶν εἰς τὴν γῆν, ὑπάρχει δ' ἐν τῇ
γῇ πολὺ πῦρ καὶ πολλὴ θερμότης, καὶ ὁ ἥλιος οὐ
μόνον τὸ ἐπιπολάζον τῆς γῆς ὑγρὸν ἕλκει, ἀλλὰ
καὶ τὴν γῆν αὐτὴν ξηραίνει θερμαίνων· τῆς δ' ἀνα-
θυμιάσεως, ὥσπερ εἴρηται, διπλῆς οὔσης, τῆς μὲν
10 ἀτμιδώδους τῆς δὲ καπνώδους, ἀμφοτέρας ἀναγ-
καῖον γίγνεσθαι. τούτων δ' ἡ μὲν ὑγροῦ πλέον
ἔχουσα πλῆθος ἀναθυμίασις ἀρχὴ τοῦ ὑομένου
ὕδατός ἐστιν, ὥσπερ εἴρηται πρότερον, ἡ δὲ ξηρὰ
τῶν πνευμάτων ἀρχὴ καὶ φύσις πάντων. ταῦτα
δὲ ὅτι τοῦτον τὸν τρόπον ἀναγκαῖον συμβαίνειν,
15 καὶ ἐξ αὐτῶν τῶν ἔργων δῆλον· καὶ γὰρ τὴν ἀνα-
θυμίασιν διαφέρειν ἀναγκαῖον, καὶ τὸν ἥλιον καὶ
τὴν ἐν τῇ γῇ θερμότητα ταῦτα ποιεῖν οὐ μόνον
δυνατὸν ἀλλ' ἀναγκαῖόν ἐστιν.

Ἐπειδὴ δ' ἕτερον ἑκατέρας τὸ εἶδος, φανερὸν ὅτι
διαφέρει, καὶ οὐχ ἡ αὐτή ἐστιν ἥ τε ἀνέμου φύσις

are two kinds of exhalation—one moist and one dry : caused by dry
of these the first is called vapour, the second has no name that applies to it as a whole, and we are compelled to apply to the whole a name which belongs to a part only and call it a kind of smoke The moist exhalation does not exist without the dry nor the dry without the moist, but we speak of them as dry or moist according as either quality predominates.

When, therefore, the sun in its circular course approaches the earth, its heat draws up the moist exhalation; when it recedes the vapour thus drawn up is condensed again by the resulting cold into water (This is why there is more rain in the winter, and more at night than by day—though this is not commonly supposed to be so because rainfall at night more often passes unnoticed than by day.) The water thus formed falls and is all distributed over the earth. Now there is in the earth a large amount of fire and heat, and the sun not only draws up the moisture on the earth's surface but also heats and so dries the earth itself; and this must produce exhalations which are of the two kinds we have described, namely vaporous and smoky. The exhalation containing the greater amount of moisture is, as we have said before,[a] the origin of rain water : the dry exhalation is the origin and natural substance of winds. That this must be the case is evident from the facts. For the exhalations that produce rain and wind must differ and it is not only possible but necessary that the sun and the warmth in the earth should produce the exhalations.

Since the two exhalations differ in kind, it is clear Rain and wind differ.
that the substance of wind and of rain water also

[a] Book I. ch. 9.

360 a
καὶ ἡ τοῦ ὑομένου ὕδατος, καθάπερ τινὲς λέγουσιν· τὸν γὰρ αὐτὸν ἀέρα κινούμενον μὲν ἄνεμον εἶναι, συνιστάμενον δὲ πάλιν ὕδωρ. καὶ γὰρ ἄτοπον εἰ ὁ περὶ ἑκάστους περικεχυμένος ἀὴρ οὗτος γίγνεται κινούμενος πνεῦμα, καὶ ὅθεν ἂν τύχῃ κινηθείς, ἄνεμος ἔσται, ἀλλ' οὐ καθάπερ τοὺς ποταμοὺς ὑπολαμβάνομεν οὐχ ὁπωσοῦν τοῦ ὕδατος εἶναι ῥέοντος, οὐδ' ἂν ἔχῃ πλῆθος, ἀλλὰ δεῖ πηγαῖον εἶναι τὸ ῥέον· οὕτω γὰρ καὶ περὶ τῶν ἀνέμων ἔχει· κινηθείη γὰρ ἂν πολὺ πλῆθος ἀέρος ὑπό τινος μεγάλης πτώσεως, οὐκ ἔχον ἀρχὴν οὐδὲ πηγήν.

'Ο μὲν οὖν ἀήρ,[1] καθάπερ ἐν τοῖς πρὸ τούτων λόγοις εἰρήκαμεν, γίγνεται ἐκ τούτων· ἡ μὲν γὰρ ἀτμὶς ὑγρὸν καὶ ψυχρόν (εὐόριστον μὲν γὰρ ὡς ὑγρόν, διὰ δὲ τὸ ὕδατος εἶναι ψυχρὸν τῇ οἰκείᾳ φύσει, ὥσπερ ὕδωρ μὴ θερμανθέν), ὁ δὲ καπνὸς θερμὸν καὶ ξηρόν· ὥστε καθάπερ ἐκ συμβόλων, συνίσταιτο ἂν ὁ ἀὴρ ὑγρὸς καὶ θερμός. μαρτυρεῖ δὲ τὰ γιγνόμενα τοῖς εἰρημένοις· διὰ γὰρ τὸ συνεχῶς μὲν μᾶλλον δὲ καὶ ἧττον καὶ πλείω καὶ
360 b ἐλάττω γίγνεσθαι τὴν ἀναθυμίασιν, ἀεὶ νέφη τε καὶ πνεύματα γίγνεται κατὰ τὴν ὥραν ἑκάστην ὡς πέφυκεν· διὰ δὲ τὸ ἐνίοτε μὲν τὴν ἀτμιδώδη γίγνεσθαι πολλαπλασίαν ὁτὲ δὲ τὴν ξηρὰν καὶ καπνώδη, ὁτὲ μὲν ἔπομβρα τὰ ἔτη γίγνεται καὶ ὑγρά,
5 ὁτὲ δὲ ἀνεμώδη καὶ αὐχμοί. ὁτὲ μὲν οὖν συμβαίνει καὶ τοὺς αὐχμοὺς καὶ τὰς ἐπομβρίας πολλοὺς ἅμα καὶ κατὰ συνεχῆ γίγνεσθαι χώραν, ὁτὲ δὲ κατὰ μέρη· πολλάκις γὰρ ἡ μὲν κύκλῳ χώρα λαμβάνει

[1] ὁ μὲν οὖν ἀήρ l. 21 . . . θερμός l. 27 post πηγήν l. 33 coll. Thurot.

differ and are not the same, as some[a] maintain: for they say that the same substance, air, is wind when in motion, water when condensed again.[b] Yet it is absurd to suppose that the air which surrounds us becomes wind simply by being in motion, and will be wind whatever the source of its motion; for we do not call a volume of water, however large, a river whatever its flow but only if it flows from a source, and the same thing is true of the winds, for a considerable volume of air might be set in motion by some large falling body, and have no origin or source.

Variations in rainfall.

Air then, as we have said before,[c] is made up of these two components, vapour which is moist and cold (it is unresistant because it is moist, and is naturally cold because derived from water, which is cold unless heated) and smoke which is hot and dry; so that air, being composed, as it were, of complementary factors, is moist and hot. The facts confirm this view. For because the exhalation continually increases and decreases, expands and contracts, clouds and winds are always being produced in their natural season; and because it is sometimes the vaporous exhalation that predominates, at other times the dry and smoky one, years are sometimes rainy and wet, at others windy and dry. And sometimes drought or rain is widespread and covers a large area of country, sometimes it is only local; for often in the country at large the

[a] Metrodorus of Chios (Diels 70 A 19).

[b] The first sentence from the next paragraph follows here in the accepted Greek text: I have transposed it, following Thurot (see critical note), as the transposition seems to make better sense of the passage.

[c] *Cf.* Book I. ch. 3, 340 b 14-32 and note *a* on p. 20, ch. 4, 341 b 6 ff.; also *De Gen. et Corr.* II. 4, and Joachim's note on 331 a 24.

360 b
τοὺς ὡραίους ὄμβρους ἢ καὶ πλείους, ἐν δέ τινι
μέρει ταύτης αὐχμός ἐστιν· ὁτὲ δὲ τοὐναντίον τῆς
κύκλῳ πάσης ἢ μετρίοις χρωμένης ὕδασιν ἢ καὶ
μᾶλλον αὐχμώσης, ἔν τι μόριον ὕδατος ἄφθονον
λαμβάνει πλῆθος. αἴτιον δ' ὅτι ὡς μὲν τὰ πολλὰ
τὸ αὐτὸ πάθος ἐπὶ πλείω διήκειν εἰκὸς χώραν,
διὰ τὸ παραπλησίως κεῖσθαι πρὸς τὸν ἥλιον τὰ
σύνεγγυς, ἐὰν μή τι διάφορον ἔχωσιν ἴδιον· οὐ μὴν
ἀλλ' ἐνίοτε κατὰ τοδὶ μὲν τὸ μέρος ἡ ξηρὰ ἀναθυ-
μίασις ἐγένετο πλείων, κατὰ δὲ τὸ ἄλλο ἡ ἀτμι-
δώδης, ὁτὲ δὲ τοὐναντίον καὶ αὐτοῦ δὲ τούτου
αἴτιον τὸ ἑκατέραν μεταπίπτειν εἰς τὴν τῆς ἐχομένης
χώρας ἀναθυμίασιν, οἷον ἡ μὲν ξηρὰ κατὰ τὴν
οἰκείαν ῥεῖ χώραν, ἡ δ' ὑγρὰ πρὸς τὴν γειτνιῶσαν,
ἢ καὶ εἰς τῶν πόρρω τινὰ τόπων ἀπεώσθη ὑπὸ
πνευμάτων· ὁτὲ δὲ αὕτη μὲν ἔμεινεν, ἡ δ' ἐναντία
ταὐτὸν ἐποίησεν. καὶ συμβαίνει τοῦτο πολλάκις,
ὥσπερ ἐπὶ τοῦ σώματος, ἐὰν ἡ ἄνω κοιλία ξηρὰ ᾖ,
τὴν κάτω ἐναντίως διακεῖσθαι, καὶ ταύτης ξηρᾶς
οὔσης ὑγρὰν εἶναι τὴν ἄνω καὶ ψυχράν, οὕτω καὶ
περὶ τοὺς τόπους ἀντιπεριίστασθαι καὶ μεταβάλλειν
τὰς ἀναθυμιάσεις.

Ἔτι δὲ μετά τε τοὺς ὄμβρους ἄνεμος ὡς τὰ πολλὰ
γίγνεται ἐν ἐκείνοις τοῖς τόποις καθ' οὓς ἂν συμ-
πέσῃ γενέσθαι τοὺς ὄμβρους, καὶ τὰ πνεύματα
παύεται ὕδατος γενομένου ταῦτα γὰρ ἀνάγκη
συμβαίνειν διὰ τὰς εἰρημένας ἀρχάς· ὕσαντός τε
γὰρ ἡ γῆ ξηραινομένη ὑπό τε τοῦ ἐν αὐτῇ θερμοῦ
καὶ ὑπὸ τοῦ ἄνωθεν ἀναθυμιᾶται, τοῦτο δ' ἦν
ἀνέμου σῶμα· καὶ ὅταν ἡ τοιαύτη ἀπόκρισις ᾖ καὶ
ἄνεμοι κατέχωσι, παυομένων διὰ τὸ ἀποκρίνεσθαι

seasonal rainfall is normal or even above the normal, while in some districts of it there is a drought; at other times, on the other hand, the rainfall in the country at large is meagre, or there is even a tendency to drought, while in a single district the rainfall is abundant in quantity. The reason is that as a rule a considerable area may be expected to be similarly affected, because neighbouring places lie in a similar relation to the sun, unless they have some local peculiarity: at the same time it may happen that at times the dry exhalation predominates in one district, the vaporous in another, while at times the opposite is the case. And the reason for this again is the movement of either of the two exhalations across to join that of the neighbouring district; the dry, for instance, may circulate in its own, the moist flow to a neighbouring district or be driven by winds still farther afield, while on other occasions the moist exhalation may remain and the dry retire. Thus it often happens that just as in the human body if the upper belly is dry the lower is in the opposite condition, and if the lower is dry the upper is cold and wet, so the exhalations undergo reciprocal replacement [a] and change of place.

Moreover, wind as a rule occurs after rain in those places in which the rain has happened to fall, and when rain falls the wind drops. These are necessary consequences of the principles we have stated. For after rain the earth is dried by its own internal heat and the heat from above and gives off exhalations which are the substance of wind. And when this separation is in process winds prevail; when they drop, because the hot element is constantly being

Wind follows rain.

[a] See Book I. ch. 12, note *b* on p. 82.

360 b
35 τὸ θερμὸν ἀεὶ καὶ ἀναφέρεσθαι εἰς τὸν ἄνω τόπον
συνίσταται ἡ ἀτμὶς ψυχομένη καὶ γίγνεται ὕδωρ·
καὶ ὅταν εἰς ταὐτὸν συνωσθῶσι τὰ νέφη καὶ ἀντι-
361 a περιστῇ εἰς αὐτὰ ἡ ψύξις, ὕδωρ γίγνεται καὶ κατα-
ψύχει τὴν ξηρὰν ἀναθυμίασιν. παύουσί τε οὖν τὰ
ὕδατα γιγνόμενα τοὺς ἀνέμους, καὶ παυομένων
αὐτὰ γίγνεται διὰ ταύτας τὰς αἰτίας.
5 Ἔτι δὲ τοῦ γίγνεσθαι μάλιστα πνεύματα ἀπό τε
τῆς ἄρκτου καὶ μεσημβρίας τὸ αὐτὸ αἴτιον· πλεῖστοι
γὰρ βορέαι καὶ νότοι γίγνονται τῶν ἀνέμων· ὁ γὰρ
ἥλιος τούτους μόνους οὐκ ἐπέρχεται τοὺς τόπους,
ἀλλὰ πρὸς τούτους καὶ ἀπὸ τούτων, ἐπὶ δυσμὰς
δὲ καὶ ἐπ᾽ ἀνατολὰς ἀεὶ φέρεται· διὸ τὰ νέφη
10 συνίσταται ἐν τοῖς πλαγίοις, καὶ γίγνεται προσ-
ιόντος μὲν ἡ ἀναθυμίασις τοῦ ὑγροῦ, ἀπιόντος δὲ
πρὸς τὸν ἐναντίον τόπον ὕδατα καὶ χειμῶνες. διὰ
μὲν οὖν τὴν φορὰν τὴν ἐπὶ τροπὰς καὶ ἀπὸ τροπῶν
θέρος γίγνεται καὶ χειμών, καὶ ἀνάγεταί τε ἄνω
15 τὸ ὕδωρ καὶ γίγνεται πάλιν· ἐπεὶ δὲ πλεῖστον μὲν
καταβαίνει ὕδωρ ἐν τούτοις τοῖς τόποις ἐφ᾽ οὓς
τρέπεται καὶ ἀφ᾽ ὧν, οὗτοι δέ εἰσιν ὅ τε πρὸς
ἄρκτον καὶ μεσημβρίαν, ὅπου δὲ πλεῖστον ὕδωρ
ἡ γῆ δέχεται, ἐνταῦθα πλείστην ἀναγκαῖον γί-
γνεσθαι τὴν ἀναθυμίασιν παραπλησίως οἷον ἐκ
χλωρῶν ξύλων καπνόν, ἡ δ᾽ ἀναθυμίασις αὕτη
20 ἄνεμός ἐστιν, εὐλόγως ἂν οὖν ἐντεῦθεν γίγνοιτο τὰ
πλεῖστα καὶ κυριώτατα τῶν πνευμάτων. καλοῦνται
δ᾽ οἱ μὲν ἀπὸ τῆς ἄρκτου βορέαι, οἱ δὲ ἀπὸ τῆς
μεσημβρίας νότοι.
Ἡ δὲ φορὰ λοξὴ αὐτῶν ἐστιν· περὶ γὰρ τὴν γῆν
25 πνέουσιν εἰς ὀρθὸν γιγνομένης τῆς ἀναθυμιάσεως,
ὅτι πᾶς ὁ κύκλῳ ἀὴρ συνέπεται τῇ φορᾷ. διὸ καὶ

separated out and rising to the upper region,[a] the vaporous exhalation is cooled and condenses and becomes water. And when the clouds are driven together and the cold is compressed within them,[b] water is formed and cools the dry exhalation. For these reasons, therefore, when rain falls the wind drops, and when the wind drops the rain falls.

Prevalence of northerly and southerly winds.

The same cause again accounts for the prevalence of winds from north and south[c]—for most winds are in fact either northerly or southerly. For over these regions alone the sun does not pass, but only approaches them or recedes from them; but its course always passes over the east and west. So clouds form in these regions bordering on its course, and when it approaches it causes exhalation of moisture, when it recedes to the opposite side, rain and storms. The sun's movement in the ecliptic is thus the cause of summer and winter, and the water is drawn up and falls again. Now the largest amount of rain falls in the regions beyond the tropics, that is, the regions north and south of them; and where the earth receives the most rainfall the exhalation must be correspondingly greatest, like the smoke from green sticks, and this exhalation is wind; so it is only to be expected that the majority of winds and the most considerable should come from these quarters. Those that come from the north are called Boreae, those that come from the south Notoi.

Celestial sphere the moving cause of winds

Winds blow horizontally; for though the exhalation rises vertically, the winds blow round the earth because the whole body of air surrounding the earth follows the motion of the heavens. So one might

[a] *Cf.* 341 a 4 and Book I. ch. 3, note *a* on p. 22.
[b] See Book I. ch. 12, note *b* on p. 82.
[c] *Cf.* ch. 5, 363 a 2-20.

361 a ἀπορήσειεν ἄν τις ποτέρωθεν ἡ ἀρχὴ τῶν πνευμάτων ἐστί, πότερον ἄνωθεν ἢ κάτωθεν· ἡ μὲν γὰρ κίνησις ἄνωθεν καὶ πρὶν πνεῖν ὁ [δ']¹ ἀὴρ ἐπίδηλος, κἂν ᾖ νέφος ἢ ἀχλύς· σημαίνει γὰρ κινουμένην πνεύματος ἀρχὴν πρὶν φανερῶς ἐληλυθέναι τὸν
30 ἄνεμον, ὡς ἄνωθεν αὐτῶν ἐχόντων τὴν ἀρχήν. ἐπεὶ δ' ἐστὶν ἄνεμος πλῆθός τι τῆς ξηρᾶς ἐκ γῆς ἀναθυμιάσεως κινούμενον περὶ τὴν γῆν, δῆλον ὅτι τῆς μὲν κινήσεως ἡ ἀρχὴ ἄνωθεν, τῆς δὲ ὕλης καὶ τῆς γενέσεως κάτωθεν· ᾗ μὲν γὰρ ῥευσεῖται τὸ ἀνιόν, ἐκεῖθεν τὸ αἴτιον· ἡ γὰρ φορὰ τῶν πορρωτέρω
35 κυρία τῆς γῆς· καὶ ἅμα κάτωθεν μὲν εἰς ὀρθὸν ἀναφέρεται, καὶ πᾶν ἰσχύει μᾶλλον ἐγγύς, ἡ δὲ τῆς
361 b γενέσεως ἀρχὴ δῆλον ὡς ἐκ τῆς γῆς ἐστιν.

Ὅτι δ' ἐκ πολλῶν ἀναθυμιάσεων συνιουσῶν κατὰ μικρόν, ὥσπερ αἱ τῶν ποταμῶν ἀρχαὶ γίγνονται νοτιζούσης τῆς γῆς, δῆλον καὶ ἐπὶ τῶν ἔργων· ὅθεν γὰρ ἑκάστοτε πνέουσιν, ἐλάχιστοι πάντες εἰσί,
5 προϊόντες δὲ καὶ πόρρω λαμπροὶ πνέουσιν. ἔτι δὲ καὶ τὰ περὶ τὴν ἄρκτον ἐν τῷ χειμῶνι νήνεμα καὶ ἄπνοα, κατ' αὐτὸν ἐκεῖνον τὸν τόπον· ἀλλὰ τὸ κατὰ μικρὸν ἀποπνέον καὶ λανθάνον ἔξω προϊὸν ἤδη πνεῦμα γίγνεται λαμπρόν.

Τίς μὲν οὖν ἐστιν ἡ τοῦ ἀνέμου φύσις καὶ πῶς
10 γίγνεται, ἔτι δὲ αὐχμῶν τε πέρι καὶ ἐπομβρίας, καὶ διὰ τίν' αἰτίαν καὶ παύονται καὶ γίγνονται μετὰ τοὺς ὄμβρους, διὰ τί τε βορέαι καὶ νότοι πλεῖστοι τῶν ἀνέμων εἰσίν, εἴρηται· πρὸς δὲ τούτοις καὶ περὶ τῆς φορᾶς αὐτῶν.

¹ om. J_{corr} O.T

raise the question whether winds originate from above or below, for their movement is derived from above, and even before they actually start to blow the air reveals their approach, even if there is cloud or mist; for these show that a wind has started to blow even before its arrival is perceptible, which seems to indicate that winds originate from above. But since a wind is a body of dry exhalation moving about the earth, it is clear that though their motion takes its origin from above the material from which they are produced comes from below Thus the direction of flow of the rising exhalation is determined from above, as the motion of the heavens controls things whose distance from the earth is considerable · at the same time the exhalation rises vertically from below, since any cause operates more strongly on its effect the nearer it is to it and the exhalation is clearly produced originally from the earth.

The facts also make it clear that winds are formed by the gradual collection of small quantities of exhalation, in the same way that rivers form when the earth is wet. For they are all least strong at their place of origin, but blow strongly as they travel farther from it. Besides, the north, that is the region immediately about the pole, is calm and windless in winter; but the wind which blows so gently there that it passes unnoticed becomes strong as it moves farther afield.

We have thus given an account of the nature and origin of the wind, and of drought and rainfall. We have given the reason why winds fall and rise after rain and why the prevailing winds are northerly and southerly: finally we have dealt with the motion of the winds.

CHAPTER V

ARGUMENT

Extreme heat and cold prevent the rise of winds, which occur when the seasons are changing (361 b 14-35). *This is shown by the Etesian winds and the fair weather winds which correspond to them* (361 b 35—362 a 31). *The south wind blows, not from the pole, but from the torrid zone. This is*

361 b 14 Ὁ δ' ἥλιος καὶ παύει καὶ συνεξορμᾷ τὰ πνεύ-
15 ματα· ἀσθενεῖς μὲν γὰρ καὶ ὀλίγας οὔσας τὰς ἀναθυμιάσεις μαραίνει τῷ πλείονι θερμῷ τὸ ἐν τῇ ἀναθυμιάσει ἔλαττον ὄν, καὶ διακρίνει. ἔτι δὲ αὐτὴν τὴν γῆν φθάνει ξηραίνων πρὶν γενέσθαι ἔκκρισιν ἀθρόαν, ὥσπερ εἰς πολὺ πῦρ ἐὰν ὀλίγον ἐμπέσῃ ὑπέκκαυμα, φθάνει πολλάκις πρὶν καπνὸν
20 ποιῆσαι κατακαυθέν. διὰ μὲν οὖν ταύτας τὰς αἰτίας καταπαύει τε τὰ πνεύματα καὶ ἐξ ἀρχῆς γίγνεσθαι κωλύει, τῇ μὲν μαράνσει καταπαύων, τῷ δὲ τάχει τῆς ξηρότητος γίγνεσθαι κωλύων· διὸ περὶ Ὠρίωνος ἀνατολὴν μάλιστα γίγνεται νηνεμία, καὶ μέχρι τῶν ἐτησίων καὶ προδρόμων. ὅλως δὲ
25 γίγνονται αἱ νηνεμίαι διὰ δύ' αἰτίας· ἢ γὰρ διὰ ψῦχος ἀποσβεννυμένης τῆς ἀναθυμιάσεως, οἷον ὅταν γένηται πάγος ἰσχυρός, ἢ καταμαραινομένης ὑπὸ τοῦ πνίγους. αἱ δὲ πλεῖσται καὶ ἐν ταῖς ἀνὰ μέσον ὥραις, ἢ τῷ μήπω ἀναθυμιᾶσθαι, ἢ τῷ ἤδη ἐξ-
30 εληλυθέναι τὴν ἀναθυμίασιν καὶ ἄλλην μήπω ἐπιρρεῖν.

Ἄκριτος δὲ καὶ χαλεπὸς ὁ Ὠρίων εἶναι δοκεῖ,

CHAPTER V

ARGUMENT (*continued*)

shown by a consideration of the two habitable zones of the earth ; one, in which we live, lies in the northern hemisphere, the other in the southern, and each has an analogous disposition of winds. The prevailing winds in our hemisphere are northerly or southerly (362 a 31—363 a 20).

Extreme heat and cold prevent the rise of winds.

THE sun both hinders and encourages the rise of winds. For when the exhalations are feeble and few its greater heat scorches up the lesser heat of the exhalation and disperses it. Also it dries up even the earth too quickly to allow the exhalation to gather in any quantity, just as a small amount of fuel thrown into a large fire is burnt up before it can produce any smoke. For these reasons, then, the sun hinders the rise of winds or prevents it altogether . it hinders it by scorching up the exhalation's heat; it prevents it by the speed with which it dries the earth. Therefore the period from about the rise of Orion[a] to the coming of the Etesian winds [b] and their precursors is generally calm. There are two general causes of calm weather : either the exhalation is quenched by cold, as in a hard frost, or it is scorched up and stifled by the heat. Calm weather in the intervening periods [c] is mostly caused by lack of exhalation or by the exhalation having passed away and not yet being replaced.

The reason why Orion is commonly regarded as a constellation which brings uncertain and stormy

[a] Early July : the morning rising.
[b] *Cf.* 361 b 35 below.
[c] *i.e.* between the cold of winter and the heat of summer.

361 b καὶ δύνων καὶ ἐπιτέλλων, διὰ τὸ ἐν μεταβολῇ ὥρας συμβαίνειν τὴν δύσιν καὶ τὴν ἀνατολήν, θέρους ἢ χειμῶνος, καὶ διὰ τὸ μέγεθος[1] τοῦ ἄστρου ἡμερῶν γίγνεται[1] πλῆθος αἱ δὲ μεταβολαὶ πάντων τα-
35 χώδεις διὰ τὴν ἀοριστίαν εἰσίν.

Οἱ δ' ἐτησίαι πνέουσι μετὰ τροπὰς καὶ κυνὸς ἐπιτολήν, καὶ οὔτε τηνικαῦτα ὅτε μάλιστα πλησιάζει
362 a ὁ ἥλιος, οὔτε ὅτε πόρρω· καὶ τὰς μὲν ἡμέρας πνέουσι, τὰς δὲ νύκτας παύονται. αἴτιον δ' ὅτι πλησίον μὲν ὢν φθάνει ξηραίνων πρὶν γενέσθαι τὴν ἀναθυμίασιν· ὅταν δ' ἀπέλθῃ μικρόν, σύμμετρος ἤδη γίγνεται ἡ ἀναθυμίασις καὶ ἡ[2] θερμότης,
5 ὥστε τὰ πεπηγότα ὕδατα τήκεσθαι, καὶ τῆς γῆς ξηραινομένης ὑπό τε τῆς οἰκείας θερμότητος καὶ ὑπὸ τῆς τοῦ ἡλίου οἷον τύφεσθαι καὶ θυμιᾶσθαι. τῆς δὲ νυκτὸς λωφῶσι διὰ τὸ τὰ πεπηγότα τηκόμενα παύεσθαι διὰ τὴν ψυχρότητα τῶν νυκτῶν. θυμιᾶται δ' οὔτε τὸ πεπηγὸς οὔτε τὸ μηδὲν ἔχον
10 ξηρόν, ἀλλ' ὅταν ἔχῃ τὸ ξηρὸν ὑγρότητα, τοῦτο θερμαινόμενον θυμιᾶται.

Ἀποροῦσι δέ τινες διὰ τί βορέαι μὲν γίγνονται συνεχεῖς, οὓς καλοῦμεν ἐτησίας, μετὰ τὰς θερινὰς τροπάς, νότοι δὲ οὕτως οὐ γίγνονται μετὰ τὰς χειμερινάς. ἔχει δὲ οὐκ ἀλόγως· γίγνονται μὲν
15 γὰρ οἱ καλούμενοι λευκόνοτοι τὴν ἀντικειμένην ὥραν, οὐχ οὕτως δὲ γίγνονται συνεχεῖς· διὸ λανθάνοντες ποιοῦσιν ἐπιζητεῖν. αἴτιον δ' ὅτι ὁ μὲν βορέας ἀπὸ τῶν ὑπὸ τὴν ἄρκτον πνεῖ τόπων, οἳ πλήρεις ὕδατος καὶ χιόνος εἰσὶ πολλῆς, ὧν τηκομένων ὑπὸ τοῦ ἡλίου μετὰ τὰς θερινὰς τροπὰς

[1] " scribe διότι διὰ τὸ μέγεθος aut pro γίνεται corrige γίνεσθαι " (Ideler). [2] ἀναθυμίασις καὶ ἡ om. E W Ap Ol Ideler.

weather when it rises and sets is that its rising and setting[a] occur at a change of season (summer or winter), and, owing to the size of the constellation, last many days: and all changes are uncertain and so unsettled.

The Etesian winds blow after the summer solstice and the rise of the Dog-star[b]; they do not blow when the sun is at its nearest nor when it is far off. They blow in the day-time and drop at night. The reason for this is that when the sun is closer it dries the earth too quickly for the exhalation to form: when it withdraws a little, the balance between its heat and the exhalation is restored, with the result that frozen water melts and the earth, dried by its own internal heat and by that of the sun, gives off smoke and fumes.[c] These winds cease at night because the coldness of the nights stops frozen water melting. Moisture that is frozen or that contains no dry constituent does not give off fumes; but a dry substance that contains moisture does so when heated

The Etesian winds.

Some people find it difficult to see why the north winds which we call Etesian blow continuously after the summer solstice, but there are no corresponding south winds after the winter solstice. But this is not without reason. For the so-called fair weather winds do blow from the south at the corresponding time in winter, but as they do not blow so continuously, they escape notice; and thus the difficulty arises. The reason for this is that the north wind blows from the polar regions, which are full of water and large quantities of snow; so the Etesian winds blow when the sun melts these, which it does just

The fair weather and Bird winds.

[a] Mid-November: the morning setting.
[b] Late July.
[c] *Cf.* 362 a 16-22 below.

362 a
μᾶλλον ἢ ἐν αὐταῖς πνέουσιν οἱ ἐτησίαι· οὕτω γὰρ καὶ τὰ πνίγη γίγνεται, οὐχ ὅταν μάλιστα πλησιάζῃ πρὸς ἄρκτον, ἀλλ' ὅταν πλείων μὲν ᾖ χρόνος θερμαίνοντι, ἔτι δὲ ἐγγύς. ὁμοίως δὲ καὶ μετὰ χειμερινὰς τροπὰς πνέουσιν οἱ ὀρνιθίαι· καὶ γὰρ οὗτοι ἐτησίαι εἰσὶν ἀσθενεῖς· ἐλάττους δὲ καὶ ὀψιαίτεροι τῶν ἐτησίων πνέουσιν· ἑβδομηκοστῇ γὰρ ἄρχονται πνεῖν διὰ τὸ πόρρω ὄντα τὸν ἥλιον ἐνισχύειν ἧττον. οὐ συνεχεῖς δ' ὁμοίως πνέουσι, διότι τὰ μὲν ἐπιπολῆς καὶ ἀσθενῆ τότε ἀποκρίνεται, τὰ δὲ μᾶλλον πεπηγότα πλείονος δεῖται θερμότητος. διὸ διαλείποντες οὗτοι πνέουσιν, ἕως ἂν ἐπὶ τροπαῖς πάλιν ταῖς θεριναῖς πνεύσωσιν οἱ ἐτησίαι, ἐπεὶ θέλει γε ὅτι μάλιστα συνεχῶς ἐντεῦθεν ἀεὶ πνεῖν ἄνεμος.

Ὁ δὲ νότος ἀπὸ τῆς θερινῆς τροπῆς πνεῖ, καὶ οὐκ ἀπὸ τῆς ἑτέρας ἄρκτου. δύο γὰρ ὄντων τμημάτων τῆς δυνατῆς οἰκεῖσθαι χώρας, τῆς μὲν πρὸς τὸν ἄνω πόλον, καθ' ἡμᾶς, τῆς δὲ πρὸς τὸν ἕτερον καὶ πρὸς μεσημβρίαν, καὶ οὔσης οἷον τυμπάνου (τοιοῦ-
362 b τον γὰρ σχῆμα τῆς γῆς ἐκτέμνουσιν αἱ ἐκ τοῦ κέντρου αὐτῆς ἀγόμεναι, καὶ ποιοῦσι δύο κώνους, τὸν μὲν ἔχοντα βάσιν τὸν τροπικόν, τὸν δὲ τὸν διὰ παντὸς φανερόν, τὴν δὲ κορυφὴν ἐπὶ τοῦ μέσου

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[a] Alex. 99. 11 identifies these with the λευκόνοτοι "fair weather winds" of a 14 above. Thus the whole passage 362 a 12-31 deals with the winds which blow after the winter solstice and correspond to the Etesian winds. They must be southerly winds, and are called "feeble Etesian" winds not because they are northerly but because they correspond to the Etesians. The name Bird wind seems to indicate a southerly wind, with which the migrant birds return in early spring. Yet *De Mundo* 395 a 4 refers to the Bird winds as northerly.

after the solstice to a greater extent than at it. In the same way the most stifling heats occur not when the sun is at its most northerly point, but when it has had longer to make its heat felt and is still fairly close. Similarly after the winter solstice the Bird winds [a] blow. These are feeble Etesian winds, blowing later and with less force than the Etesian winds proper. They do not begin to blow till the seventieth day after the solstice, because the sun is then farther off and so has less power. They do not blow so continuously because at that time evaporation is confined to surface substances easily evaporated, and what is frozen to a greater degree requires a greater degree of heat. So they blow intermittently until the Etesian winds rise again at the summer solstice; for from then onwards the wind tends to blow almost constantly.

The habitable zones of the earth.

But the south wind blows from the summer tropic and not from the south pole. For there are two habitable sectors of the earth's surface, one, in which we live, towards the upper pole,[b] the other towards the other, that is the south pole. These sectors are drum-shaped—for lines running from the centre of the earth cut out this shaped figure on its surface: they form two cones, one having the tropic as its base, the other the ever-visible circle,[c] while their vertex is the centre of the earth; and two cones

[b] But *cf. De Caelo* ii. 2, 285 b 15.

[c] Strictly, this should mean the circumpolar stars, which, as the O.T. points out, and as Aristotle must surely have known (*cf. De Caelo* ii. 14, 297 b 30 ff.), vary with latitude, and therefore do not "serve the purpose of delineating zones at all well." Aristotle probably means the Arctic circle (Ideler ii. p. 562), though this way of referring to it is confusing.

362 b τῆς γῆς· τὸν αὐτὸν δὲ τρόπον πρὸς τὸν κάτω πόλον ἕτεροι δύο κῶνοι τῆς γῆς ἐκτμήματα ποιοῦσι.

Ταῦτα δ' οἰκεῖσθαι μόνα δυνατόν, καὶ οὔτ' ἐπέκεινα τῶν τροπῶν (σκιὰ γὰρ οὐκ ἂν ἦν πρὸς ἄρκτον, νῦν δ' ἀοίκητοι πρότερον γίγνονται οἱ τόποι πρὶν ἢ ὑπολείπειν ἢ μεταβάλλειν τὴν σκιὰν πρὸς μεσημβρίαν) τά θ' ὑπὸ τὴν ἄρκτον ὑπὸ ψύχους ἀοίκητα.

[Φέρεται δὲ καὶ ὁ στέφανος κατὰ τοῦτον τὸν τόπον· φαίνεται γὰρ ὑπὲρ κεφαλῆς γιγνόμενος ἡμῖν, ὅταν ᾖ κατὰ τὸν μεσημβρινόν.][1]

Διὸ καὶ γελοίως γράφουσι νῦν τὰς περιόδους τῆς γῆς· γράφουσι γὰρ κυκλοτερῆ τὴν οἰκουμένην, τοῦτο δ' ἐστὶν ἀδύνατον κατά τε τὰ φαινόμενα καὶ κατὰ τὸν λόγον. ὅ τε γὰρ λόγος δείκνυσιν ὅτι ἐπὶ

[1] seclusit O.T.

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[a] It is difficult to give sense or point to this remark, which the O.T. brackets as a "learned interpolation": *cf.* Heidel, *op. cit.* p. 96, note 204.

[b] *Cf.* Thomson, *Ancient Geography*, pp. 97-99.

constructed in the same way towards the lower pole cut out corresponding segments on the earth's surface.

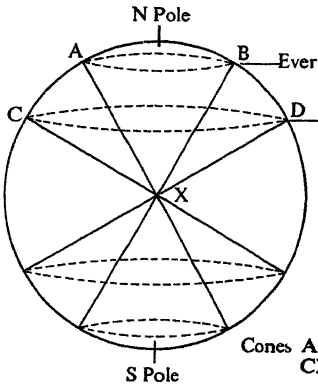

Fig. 1

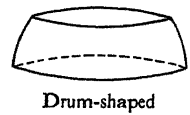

Fig. 2

These are the only habitable regions ; for the lands beyond the tropics are uninhabitable, as there the shadow would not fall towards the north, and we know that the earth ceases to be habitable before the shadow disappears or falls towards the south, while the lands beneath the Bear are uninhabitable because of the cold.

[The Crown too passes over this region, for it appears to us to be directly overhead when it is on our meridian.] [a]

The dimensions of these zones.

The way in which present maps of the world are drawn is therefore absurd. For they represent the inhabited earth as circular,[b] which is impossible both on factual and theoretical grounds. For theoretical

362 b πλάτος μὲν ὥρισται, τὸ δὲ κύκλῳ συνάπτειν ἐνδέχεται διὰ τὴν κρᾶσιν,—οὐ γὰρ ὑπερβάλλει τὰ καύματα καὶ τὸ ψῦχος κατὰ μῆκος, ἀλλ' ἐπὶ πλάτος, ὥστ' εἰ μή που κωλύει θαλάττης πλῆθος, ἅπαν εἶναι πορεύσιμον,—καὶ κατὰ τὰ φαινόμενα περί τε τοὺς πλοῦς καὶ τὰς πορείας· πολὺ γὰρ τὸ μῆκος διαφέρει τοῦ πλάτους. τὸ γὰρ ἀπὸ Ἡρακλείων στηλῶν μέχρι τῆς Ἰνδικῆς τοῦ ἐξ Αἰθιοπίας πρὸς τὴν Μαιῶτιν καὶ τοὺς ἐσχατεύοντας τῆς Σκυθίας τόπους πλέον ἢ πέντε πρὸς τρία τὸ μέγεθός ἐστιν, ἐάν τέ τις τοὺς πλοῦς λογίζηται καὶ τὰς ὁδούς, ὡς ἐνδέχεται λαμβάνειν τῶν τοιούτων τὰς ἀκριβείας. καίτοι ἐπὶ πλάτος μὲν μέχρι τῶν ἀοικήτων ἴσμεν τὴν οἰκουμένην· ἔνθα μὲν γὰρ διὰ ψῦχος οὐκέτι κατοικοῦσιν, ἔνθα δὲ διὰ τὴν ἀλέαν. τὰ δὲ τῆς Ἰνδικῆς ἔξω καὶ τῶν στηλῶν τῶν Ἡρακλείων διὰ τὴν θάλατταν οὐ φαίνεται συνείρειν τῷ[1] συνεχῶς εἶναι πᾶσαν οἰκουμένην).

Ἐπεὶ δ' ὁμοίως ἔχειν ἀνάγκη τόπον τινὰ πρὸς τὸν ἕτερον πόλον ὥσπερ ὃν ἡμεῖς οἰκοῦμεν πρὸς τὸν ὑπὲρ ἡμῶν, δῆλον ὡς ἀνάλογον ἕξει τά τ' ἄλλα καὶ τῶν πνευμάτων ἡ στάσις· ὥστε καθάπερ ἐνταῦθα βορέας ἐστίν, κἀκείνοις ἀπὸ τῆς ἐκεῖ ἄρκτου τις ἄνεμος οὕτως ὤν, ὃν οὐδὲν δυνατὸν διέχειν δεῦρο, ἐπεὶ οὐδ' ὁ βορέας οὗτος εἰς τὴν ἐνταῦθα
363 a οἰκουμένην πᾶσάν [ἐστιν][2] ἔστιν γὰρ ὥσπερ ἀπόγειον τὸ πνεῦμα τὸ βόρει ι [ζως ὁ βορέας οὗτος εἰς

[1] συνείρειν, τῷ Fobes. [2] ἐστιν om. E_1 O.T.

calculation shows that it is limited in breadth but could, as far as climate is concerned, extend round the earth in a continuous belt for it is not difference of longitude but of latitude that brings great variations of temperature, and if it were not for the ocean which prevents it, the complete circuit could be made. And the facts known to us from journeys by sea and land also confirm the conclusion that its length is much greater than its breadth. For if one reckons up these voyages and journeys, so far as they are capable of yielding any accurate information, the distance from the Pillars of Heracles to India exceeds that from Aethiopia to Lake Maeotis and the farthest parts of Scythia by a ratio greater than that of 5 to 3. Yet we know the whole breadth of the habitable world up to the unhabitable regions which bound it, where habitation ceases on the one side because of the cold, on the other because of the heat; while beyond India and the Pillars of Heracles it is the ocean which severs the habitable land and prevents it forming a continuous belt round the globe.[a]

Winds in the two zones correspond.

Since, then, there must be a region which bears to the other pole the same relation as that which we inhabit bears to our pole, it is clear that this region will be analogous to ours in the disposition of winds as well as in other respects. Thus, just as we have a north wind here, so they have a similar wind which blows from their pole, and which cannot possibly reach us; for our own north wind does not blow right across the region in which we live,[b] being in

[a] So the disproportion of length and breadth may be still greater: *cf. De Caelo* ii. 14, 298 a 9.

[b] Omit *ἐστιν* and understand *διέχει* from b 35: it seems unnecessary to alter *διέχειν* (b 35) to *διήκειν* with the O.T. as *διέχειν* can bear the meaning required, to reach to.

363 a τὴν ἐνταῦθα οἰκουμένην πνεῖ].[1] ἀλλὰ διὰ τὸ τὴν οἴκησιν κεῖσθαι ταύτην πρὸς ἄρκτον, πλεῖστοι βορέαι πνέουσιν. ὅμως δὲ καὶ ἐνταῦθα ἐλλείπει καὶ οὐ δύναται πόρρω διήκειν, ἐπεὶ περὶ τὴν ἔξω Λιβύης θάλατταν τὴν νοτίαν, ὥσπερ ἐνταῦθα οἱ βορέαι καὶ οἱ νότοι πνέουσιν, οὕτως ἐκεῖ εὖροι καὶ ζέφυροι διαδεχόμενοι συνεχεῖς ἀεὶ πνέουσιν.

Ὅτι μὲν οὖν ὁ νότος οὐκ ἔστιν ὁ ἀπὸ τοῦ ἑτέρου πόλου πνέων ἄνεμος, δῆλον. ἐπεὶ δ' οὔτ' ἐκεῖνος, οὔτε ὁ ἀπὸ χειμερινῆς τροπῆς (δέοι γὰρ ἂν ἄλλον ἀπὸ θερινῆς εἶναι τροπῆς· οὕτως γὰρ τὸ ἀνάλογον ἀποδώσει· νῦν δ' οὐκ ἔστιν· εἷς γὰρ μόνος φαίνεται πνέων ἐκ τῶν ἐκεῖθεν τόπων)· ὥστ' ἀνάγκη τὸν ἀπὸ τοῦ κατακεκαυμένου τόπου πνέοντα ἄνεμον εἶναι νότον. ἐκεῖνος δ' ὁ τόπος διὰ τὴν τοῦ ἡλίου γειτνίασιν οὐκ ἔχει ὕδατα καὶ νομάς,[2] αἳ διὰ τὴν τῆξιν[3] ποιήσουσιν ἐτησίας· ἀλλὰ διὰ τὸ τὸν τόπον εἶναι πολὺ πλείω ἐκεῖνον καὶ ἀναπεπταμένον, μείζων καὶ πλείων καὶ μᾶλλον ἀλεεινὸς ἄνεμος ὁ νότος ἐστὶ τοῦ βορέου, καὶ διήκει μᾶλλον δεῦρο ἢ οὗτος ἐκεῖ.

Τίς μὲν οὖν αἰτία τούτων ἐστὶ τῶν ἀνέμων, καὶ πῶς ἔχουσι πρὸς ἀλλήλους, εἴρηται.

[1] secl. Fobes.
[2] *χίονας* O.T : cf. 362 a 18, 364 a 8-10.
[3] *πῆξιν* Ap Ol Fobes : *τῆξιν* codd.

this like a land wind. But because our region of habitation lies towards the north, most of our winds are north winds.[a] Yet even in our region they fail and are not strong enough to travel far; for in the sea south of Libya east and west winds [b] alternate with each other continuously, just as here it is north and south winds that blow.

This proves that our south wind is not the wind that blows from the south pole. But it does not blow from the winter tropic any more than from the south pole. For there would have to be a wind from the summer tropic [c] if the correspondence is to be complete; but in fact there is no such wind, but one wind only that blows from this region. The south wind must therefore be the wind that blows from the torrid zone. This region because of its proximity to the sun has no streams or pasture land to produce Etesian winds by thawing [d]; but because the region is greater in extent and open, the south wind is greater, stronger and warmer than the north and reaches farther northwards than the north wind southwards.[e]

So much for the cause and mutual relations of these winds.

[a] *Cf.* 361 a 5.

[b] Perhaps the Trade Winds in the Indian Ocean.

[c] Blowing southwards.

[d] The O.T.'s τῆξιν is supported by 362 a 18 and 364 a 8-10, and has MS. authority: but though the parallel passages also suggest χίονας for νομάς, MS. authority for this change is lacking.

[e] *Cf.* 361 a 5 ff.; and contrast 364 a 5-10.

CHAPTER VI

ARGUMENT

The different winds and their directions are enumerated with the aid of a diagram (363 a 21—364 a 4). *Why most winds are northerly* (364 a 4-13). *A more general classifica-*

363 a 21 Περὶ δὲ θέσεως αὐτῶν, καὶ τίνες ἐναντίοι τίσι, καὶ ποίους ἅμα πνεῖν ἐνδέχεται καὶ ποίους οὔ, ἔτι δὲ καὶ τίνες καὶ πόσοι τυγχάνουσιν ὄντες, καὶ πρὸς τούτοις περὶ τῶν ἄλλων παθημάτων ὅσα μὴ συμ-
25 βέβηκεν ἐν τοῖς προβλήμασιν εἰρῆσθαι τοῖς κατὰ μέρος, νῦν λέγωμεν.

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[a] With this chapter *cf. De Mundo*, ch. 4 and *Vent. Sit. et Appp.*; and see D'Arcy Thompson, "The Greek Winds," in *C.R.* xxxii (1918), pp. 49-56.

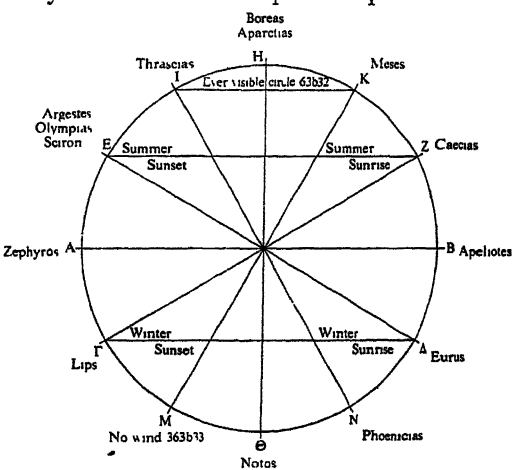
[b] *Cf. Problems* xxvi. *passim.*

CHAPTER VI

ARGUMENT (*continued*)

tion of the winds by the main points of the compass (364 a 13-27). *Miscellaneous characteristics of the winds described* (364 a 27—365 a 13).

LET us go on to the positions of the winds [a] and their mutual relations of opposition, and describe which kinds can blow simultaneously and which cannot and what are their names and numbers, besides dealing with any other of their characteristics that have not already been treated as separate "problems." [b] Diagrammatic exposition.



The *Vent. Sit.* supplies at M Leuconotos, the *De Mundo* Libonotos. while for the doubtful (*cf.* 364 a 3) Phoenicias *De Mundo* 393 b 33 has Euronotos, which should also probably be read in *Vent. Sit.* 973 b 7 (O.T. note *ad loc.*).

363 a

Δεῖ δὲ περὶ τῆς θέσεως ἅμα τοὺς λόγους ἐκ τῆς ὑπογραφῆς θεωρεῖν. γέγραπται μὲν οὖν, τοῦ μᾶλλον εὐσήμως ἔχειν, ὁ τοῦ ὁρίζοντος κύκλος· διὸ καὶ στρογγύλος. δεῖ δὲ νοεῖν αὐτὸν[1] τὸ ἕτερον ἔκτμημα τὸ ὑφ' ἡμῶν οἰκούμενον· ἔσται γὰρ κά-
30 κεῖνο διελεῖν τὸν αὐτὸν τρόπον. ὑποκείσθω δὲ πρῶτον μὲν ἐναντία κατὰ τόπον εἶναι τὰ πλεῖστον ἀπέχοντα κατὰ τόπον, ὥσπερ κατ' εἶδος ἐναντία τὰ πλεῖστον ἀπέχοντα κατὰ τὸ εἶδος· πλεῖστον δ' ἀπέχει κατὰ τόπον τὰ κείμενα πρὸς ἄλληλα κατὰ διάμετρον.

Ἔστω οὖν τὸ μὲν ἐφ' ᾧ Α δυσμὴ ἰσημερινή,
363 b ἐναντίος δὲ τούτῳ τόπος, ἐφ' οὗ τὸ Β, ἀνατολὴ ἰσημερινή· ἄλλη δὲ διάμετρος ταύτην πρὸς ὀρθὴν τέμνουσα, ἧς τὸ ἐφ' οὗ Η ἔστω ἄρκτος· τούτῳ δ' ἐναντίον ἐξ ἐναντίας, τὸ ἐφ' οὗ Θ, μεσημβρία· τὸ
5 δ' ἐφ' οὗ Ζ ἀνατολὴ θερινή, τὸ δ' ἐφ' ᾧ Ε δυσμὴ θερινή, τὸ δ' ἐφ' οὗ Δ ἀνατολὴ χειμερινή, τὸ δ' ἐφ' οὗ Γ δυσμὴ χειμερινή ἀπὸ δὲ τοῦ Ζ ἤχθω διάμετρος ἐπὶ τὸ Γ. καὶ ἀπὸ τοῦ Δ ἐπὶ τὸ Ε. ἐπεὶ οὖν τὰ μὲν πλεῖστον ἀπέχοντα κατὰ τόπον ἐναντία κατὰ τόπον, πλεῖστον δ' ἀπέχει τὰ κατὰ διάμετρον,
10 ἀναγκαῖον καὶ τῶν πνευμάτων ταῦτα ἀλλήλοις ἐναντία εἶναι, ὅσα κατὰ διάμετρόν ἐστιν.

Καλεῖται δὲ κατὰ τὴν θέσιν τῶν τόπων τὰ πνεύματα ὧδε· ζέφυρος μὲν τὸ ἀπὸ τοῦ Α· τοῦτο γὰρ δυσμὴ ἰσημερινή. ἐναντίος δὲ τούτῳ ἀπηλιώτης ἀπὸ τοῦ Β· τοῦτο γὰρ ἀνατολὴ ἰσημερινή.
15 βορέας δὲ ⟨καὶ⟩[2] ἀπαρκτίας ἀπὸ τοῦ Η· ἐνταῦθα

[1] αὐτὸν F_1 H N O.T. : αὐτοῦ cett. Fobes.
[2] καὶ habent $E_{rec.}$ Ald : ὁ καὶ $F_{rec.}$: om. cett.

The treatment of their position must be followed with the help of the diagram. For the sake of clarity we have drawn the circle of the horizon ; that is why our figure is round. And it must be supposed to represent the section of the earth's surface in which we live ; for the other section could be divided in a similar way. Let us first define things as spatially opposite when they are farthest removed from each other in space (just as things formally opposite are things farthest removed from each other in form) ; and things are farthest removed from each other in space when they lie at opposite ends of the same diameter.

Let the point A be the equinoctial sunset, and the point B its opposite, the equinoctial sunrise. Let another diameter cut this at right angles, and let the point H on this be the north and its diametrical opposite Θ be the south. Let the point Z be the summer sunrise, the point E the summer sunset, the point Δ the winter sunrise, the point Γ the winter sunset. And from Z let the diameter be drawn to Γ, from Δ to E. Since, then, things spatially farthest removed from each other are spatially opposite, and things diametrically opposed are farthest removed, those winds must be mutually opposite which are opposed diametrically.

The names of the winds corresponding to these positions are as follows : Zephyros blows from A, for this is the equinoctial sunset. Its opposite is Apeliotes which blows from B, the equinoctial sunrise. Boreas or [a] Aparctias blows from H, the north. Its opposite

[a] Omitting καί the O.T. translates " the true north wind called Aparctias."

363 b γὰρ ἡ ἄρκτος. ἐναντίος δὲ τούτῳ νότος ἀπὸ τοῦ Θ· μεσημβρία τε γὰρ αὕτη ἀφ' ἧς πνεῖ, καὶ τὸ Θ τῷ Η ἐναντίον· κατὰ διάμετρον γάρ. ἀπὸ δὲ τοῦ Ζ καικίας· αὕτη γὰρ ἀνατολὴ θερινή. ἐναντίος δ' οὐχ ὁ ἀπὸ τοῦ Ε πνέων, ἀλλ' ὁ ἀπὸ τοῦ Γ λίψ· 20 οὗτος γὰρ ἀπὸ δυσμῆς χειμερινῆς, ἐναντίος δὲ τούτῳ (κατὰ διάμετρον γὰρ κεῖται). ἀπὸ δὲ τοῦ Δ εὖρος· οὗτος γὰρ ἀπ' ἀνατολῆς χειμερινῆς πνεῖ, γειτνιῶν τῷ νότῳ· διὸ καὶ πολλάκις εὐρόνοτοι λέγονται πνεῖν. ἐναντίος δὲ τούτῳ οὐχ ὁ ἀπὸ τοῦ Γ λίψ, ἀλλ' ὁ ἀπὸ τοῦ Ε, ὃν καλοῦσιν οἱ μὲν 25 ἀργέστην, οἱ δ' ὀλυμπίαν, οἱ δὲ σκίρωνα· οὗτος γὰρ ἀπὸ δυσμῆς θερινῆς πνεῖ, καὶ κατὰ διάμετρον αὐτῷ κεῖται μόνος.

Οὗτοι μὲν οὖν οἱ κατὰ διάμετρόν τε κείμενοι ἄνεμοι καὶ οἷς εἰσιν ἐναντίοι· ἕτεροι δ' εἰσὶν καθ' οὓς οὐκ ἔστιν ἐναντία πνεύματα. ἀπὸ μὲν γὰρ τοῦ Ι ὃν καλοῦσι θρασκίαν· οὗτος γὰρ μέσος ἀργέστου 30 καὶ ἀπαρκτίου· ἀπὸ δὲ τοῦ Κ ὃν καλοῦσιν μέσην· οὗτος γὰρ μέσος καικίου καὶ ἀπαρκτίου. ἡ δὲ τοῦ ΙΚ διάμετρος βούλεται μὲν κατὰ τὸν διὰ παντὸς εἶναι φαινόμενον, οὐκ ἀκριβοῖ δέ. ἐναντία δὲ τούτοις οὐκ ἔστι τοῖς πνεύμασιν, οὔτε τῷ μέσῃ (ἔπνει 364 a γὰρ ἄν τις ἐφ' οὗ τὸ Μ· τοῦτο γὰρ κατὰ διάμετρον) οὔτε τῷ Ι, τῷ θρασκίᾳ (ἔπνει γὰρ ἂν ἀπὸ τοῦ Ν· τοῦτο γὰρ κατὰ διάμετρον τὸ σημεῖον, εἰ μὴ ἀπ' αὐτοῦ καὶ ἐπ' ὀλίγον πνεῖ τις ἄνεμος, ὃν καλοῦσιν οἱ περὶ τὸν τόπον ἐκεῖνον φοινικίαν).

5 Τὰ μὲν οὖν κυριώτατα καὶ διωρισμένα πνεύματα ταῦτ' ἐστὶ καὶ τοῦτον τέτακται τὸν τρόπον· τοῦ δ' εἶναι πλείους ἀνέμους ἀπὸ τῶν πρὸς ἄρκτον τόπων

is Notos which blows from Θ, the south, Θ and H being diametrically opposed. From Z blows Caecias, that is, from the summer sunrise. Its opposite is not the wind blowing from E, but the wind from Γ, Lips, which blows from the winter sunset, and so is opposite to Caecias, being diametrically opposed to it. From Δ blows Eurus, for it blows from the winter sunrise and is the neighbour of Notos; so people often speak of the Euronotoi blowing. Its opposite is not Lips, the wind from Γ, but the wind from E called sometimes Argestes, sometimes Olympias, sometimes Sciron. For it blows from the summer sunset and is the only diametrical opposite to Eurus.

Most winds northerly.

These, then, are the winds which have diametrical opposites; but there are others which have no winds opposite them. From I blows the wind they call Thrascias, which lies between Argestes and Aparctias: from K the wind they call Meses, which lies between Caecias and Aparctias. The chord IK nearly corresponds to the ever-visible circle [a] but fails to do so exactly. There are no opposites to those winds: neither to Meses, otherwise there would be a wind from the point M diametrically opposite, nor to Thrascias at I, otherwise there would be a wind from N, the point diametrically opposite, which there is not, except perhaps a local wind called by the inhabitants Phoenicias.

These, then, are the most important different winds and their positions. There are two reasons for there being more winds from the northerly than from the

[a] *Cf.* ch. 5, note *c* on p. 179.

364 a ἢ τῶν πρὸς μεσημβρίαν αἴτιον τό τε τὴν οἰκουμένην ὑποκεῖσθαι πρὸς τοῦτον τὸν τόπον, καὶ ὅτι πολλῷ πλέον ὕδωρ καὶ χιὼν ἀπωθεῖται εἰς τοῦτο τὸ μέρος διὰ τὸ ἐκεῖνα ὑπὸ τὸν ἥλιον εἶναι καὶ τὴν ἐκείνου φοράν, ὧν τηκομένων εἰς τὴν γῆν καὶ θερμαινομένων ὑπὸ τοῦ ἡλίου καὶ τῆς γῆς ἀναγκαῖον πλείω καὶ ἐπὶ πλείω τόπον γίγνεσθαι τὴν ἀναθυμίασιν διὰ ταύτην τὴν αἰτίαν.

Ἔστι δὲ τῶν εἰρημένων πνευμάτων βορέας μὲν ὅ τ' ἀπαρκτίας κυριώτατα, καὶ θρασκίας καὶ μέσης· ὁ δὲ καικίας κοινὸς ἀπηλιώτου καὶ βορέου· νότος δὲ ὅ τε ἰθαγενὴς ὁ ἀπὸ μεσημβρίας καὶ λίψ· ἀπηλιώτης δὲ ὅ τε ἀπ' ἀνατολῆς ἰσημερινῆς καὶ ὁ εὖρος· ὁ δὲ φοινικίας κοινός· ζέφυρος δὲ ὅ τε ἰθαγενὴς καὶ ὁ ἀργέστης καλούμενος. ὅλως δὲ τὰ μὲν βόρεια τούτων καλεῖται, τὰ δὲ νότια προστίθεται δὲ τὰ μὲν ζεφυρικὰ τῷ βορέᾳ (ψυχρότερα γὰρ διὰ τὸ ἀπὸ δυσμῶν πνεῖν), νότῳ δὲ τὰ ἀπηλιωτικά (θερμότερα γὰρ διὰ τὸ ἀπ' ἀνατολῆς πνεῖν). διωρισμένων οὖν τῷ ψυχρῷ καὶ τῷ θερμῷ καὶ ἀλεεινῷ τῶν πνευμάτων οὕτως ἐκάλεσαν. θερμότερα μὲν τὰ ἀπὸ τῆς ἕω τῶν ἀπὸ δυσμῆς, ὅτι πλείω χρόνον ὑπὸ τὸν ἥλιόν ἐστι τὰ ἀπ' ἀνατολῆς· τὰ δ' ἀπὸ δυσμῆς ἀπολείπει τε θᾶττον καὶ πλησιάζει τῷ τόπῳ ὀψιαίτερον.

Οὕτω δὲ τεταγμένων τῶν ἀνέμων, δῆλον ὅτι ἅμα πνεῖν τοὺς μὲν ἐναντίους οὐχ οἷόν τε (κατὰ διάμετρον γάρ· ἄτερος οὖν παύσεται ἀποβιασθείς), τοὺς δὲ μὴ οὕτως κειμένους πρὸς ἀλλήλους οὐδὲν κωλύει, οἷον τὸν Ζ καὶ Δ. διὰ τοῦτο ἅμα πνέουσιν

southerly regions [a] First, our inhabited region lies towards the north; second, far more rain and snow is pushed up into this region because the other lies beneath the sun and its course. These melt and are absorbed by the earth and when subsequently heated by the sun and the earth's own heat cause a greater and more extensive exhalation [b]

Classification by points of compass

Of the winds thus described the truest north winds are Aparctias, Thrascias and Meses. Caecias is part east and part north. South are the winds that come from due south and Lips. East are the winds that come from the equinoctial sunrise and Eurus. Phoenicias is part south, part east. West is the wind from due west and also the wind called Argestes. There is a general classification of these winds into northerly and southerly: westerly winds are counted as northerly, being colder because they blow from the sunset; easterly winds are counted as southerly, being warmer because they blow from the sunrise. Winds are thus called northerly and southerly according to this division into cold and hot or warm. Winds from the sunrise are warmer than winds from the sunset, because those from the sunrise are exposed to the sun for longer; while those from the sunset are reached by the sun later and it soon leaves them. [c]

Miscellaneous characteristics.

This being the arrangement of the winds, it is clear that opposite winds cannot blow at the same time, for one or other would be overpowered and stop blowing; but there is nothing to prevent two winds not so related blowing at once, as, for instance, the winds from Z and Δ. So two winds may sometimes

[a] *Cf.* 361 a 4, 363 a 2.

[b] *Cf.* 361 a 6 ff., 362 a 3, a 17 · contrast 363 a 15.

[c] "A poor argument even for a flat-earth man; and for Aristotle with his round earth lamentable. Perhaps the sentence should be condemned" (O.T.).

be favourable to ships making for the same point, though they are not blowing from the same quarter and are not the same wind.

As a rule, opposite winds blow in opposite seasons: for instance, at the time of the vernal equinox Caecias and winds from north of the summer sunrise prevail; in the autumn Lips; at the summer solstice Zephyros, at the winter Eurus.

Aparctias, Thrascias and Argestes are the winds that most often interrupt and stop others. For because their source is nearest to us they blow with the greatest frequency and strength of all winds. They therefore bring the fairest weather of all, for blowing from near at hand they force other winds away and stop them, and by blowing away any clouds that have formed make fair weather. If, however, they happen also to be very cold they do not bring fair weather; for if they are cold rather than strong they freeze the clouds before they can drive them away. Caecias is not a fair-weather wind because it turns back on itself[a]—hence the proverb "Drawing it to himself as Caecias clouds."

When a wind drops it is succeeded by its neighbour in the direction of the sun's movement; for what lies next to the source of a movement is set in motion first and the source of the winds moves round with the sun.[b]

Opposite winds produce either the same or opposite effects: for instance, Lips and Caecias (which some

[a] *Cf. Problems* xxvi. 1 and 29. Caecias, "descending from above, sweeps in a circular course up into the sky, and thence returns to the point from which it started" (O.T. note *ad Problems* xxvi. 1).

[b] Presumably because the sun is the controlling cause of the exhalation which produces wind.

364 b
καλοῦσιν [καὶ εὖρος, ὃν ἀπηλιώτην].[1] ξηροὶ δὲ ἀργέστης καὶ εὖρος· ἀπ' ἀρχῆς δὲ οὗτος ξηρός, τελευτῶν δὲ ὑδατώδης.

Νιφετώδης δὲ μέσης καὶ ἀπαρκτίας μάλιστα· οὗτοι γὰρ ψυχρότατοι. χαλαζώδεις δὲ ἀπαρκτίας καὶ θρασκίας καὶ ἀργέστης. καυματώδης δὲ νότος καὶ ζέφυρος καὶ εὖρος. νέφεσι δὲ πυκνοῦσι τὸν οὐρανὸν καικίας μὲν σφόδρα, λίψ δὲ ἀραιοτέροις, καικίας μὲν διά τε τὸ ἀνακάμπτειν πρὸς αὐτὸν καὶ διὰ τὸ κοινὸς εἶναι βορέου καὶ εὔρου, ὥστε διὰ μὲν τὸ ψυχρὸς εἶναι πηγνὺς τὸν ἀτμίζοντα ἀέρα συνίστησι, διὰ δὲ τὸ τῷ τόπῳ ἀπηλιωτικὸς εἶναι ἔχει πολλὴν ὕλην καὶ ἀτμίδα ἣν προωθεῖ. αἴθριοι δὲ ἀπαρκτίας, θρασκίας, ἀργέστης· ἡ δ' αἰτία εἴρηται πρότερον. ἀστραπὰς δὲ ποιοῦσιν μάλιστα οὗτοί τε καὶ ὁ μέσης· διὰ μὲν γὰρ τὸ ἐγγύθεν πνεῖν ψυχροί εἰσιν, διὰ δὲ τὸ ψυχρὸν ἀστραπὴ γίγνεται· ἐκκρίνεται γὰρ συνιόντων τῶν νεφῶν. διὸ καὶ
365 a ἔνιοι τῶν αὐτῶν τούτων χαλαζώδεις εἰσίν· ταχὺ γὰρ πηγνύουσιν.

Ἐκνεφίαι δὲ γίγνονται μετοπώρου μὲν μάλιστα, εἶτα ἔαρος, καὶ μάλιστα ἀπαρκτίας καὶ θρασκίας καὶ ἀργέστης. αἴτιον δ' ὅτι οἱ ἐκνεφίαι γίγνονται μάλιστα ὅταν τῶν ἄλλων πνεόντων ἐμπίπτωσιν ἕτεροι, οὗτοι δὲ μάλιστα ἐμπίπτουσιν τοῖς ἄλλοις πνέουσιν· ἡ δ' αἰτία εἴρηται καὶ τούτου πρότερον.

Οἱ δ' ἐτησίαι περιίστανται τοῖς μὲν περὶ δυσμὰς οἰκοῦσιν ἐκ τῶν ἀπαρκτίων εἰς θρασκίας καὶ

[1] seclusit O.T.

call Hellespontias) are both wet winds.[a] Dry are Argestes and Eurus—the latter, however, though it starts by being dry, ends up by being rainy.

Meses and Aparctias are the most snowy, because they are the coldest. Aparctias, Thrascias and Argestes bring hail. Notos, Zephyros and Eurus bring heat. Caecias fills the sky with thick clouds, Lips with thinner. Caecias does this because it turns back on itself, and because it is part north and part east and so, being cold, collects and freezes the vaporized air, and being easterly in position has a great deal of vapour as material which it drives before it Aparctias, Thrascias and Argestes are fair-weather winds for the reason we have given before.[b] They and Meses most often produce lightning. For they are cold because their origin is near, and lightning is produced by cold, being driven out by the condensation of the clouds.[c] For this reason some of these same winds sometimes bring hail, for they freeze quickly.

Hurricanes occur most often in autumn, and next in spring: and Aparctias, Thrascias and Argestes most often cause them. The reason for this is that hurricanes are usually the result of one wind falling on another while it is still blowing, and these are the winds that do this most often. Why they do it we have already explained.[d]

The Etesian winds veer round, for people living in the west, from Aparctias to Thrascias, Argestes

[a] I omit the words *καὶ εὖρος, ὃν ἀπηλιώτην* with the O.T., since the argument requires that *pairs* of contrary winds should be named and the introduction of a *third* wind makes nonsense.

[b] 364 b 7.

[c] *Cf.* below, ch. 9.

[d] 364 b 3.

365 a ἀργέστας καὶ ζεφύρους [(ὁ γὰρ ἀπαρκτίας ζέφυρός ἐστιν),][1] ἀρχόμενοι μὲν ἀπὸ τῆς ἄρκτου,
10 τελευτῶντες δ' εἰς τοὺς πόρρω· τοῖς δὲ πρὸς ἕω περιίστανται μέχρι τοῦ ἀπηλιώτου.

Περὶ μὲν οὖν ἀνέμων, τῆς τε ἐξ ἀρχῆς αὐτῶν γενέσεως καὶ οὐσίας καὶ τῶν συμβαινόντων κοινῇ τε παθημάτων καὶ περὶ ἕκαστον, τοσαῦθ' ἡμῖν εἰρήσθω.

CHAPTER VII

ARGUMENT

Earthquakes. The views of Anaxagoras (365 a 18-35),

365 a 14 Περὶ δὲ σεισμοῦ καὶ κινήσεως γῆς μετὰ ταῦτα
15 λεκτέον· ἡ γὰρ αἰτία τοῦ πάθους ἐχομένη τούτου τοῦ γένους ἐστίν.

Ἔστι δὲ τὰ παρειλημμένα μέχρι γε τοῦ νῦν χρόνου τρία καὶ παρὰ τριῶν. Ἀναξαγόρας τε γὰρ ὁ Κλαζομένιος καὶ πρότερον Ἀναξιμένης ὁ Μιλήσιος ἀπεφήναντο, καὶ τούτων ὕστερον Δημόκριτος ὁ Ἀβδηρίτης.

20 Ἀναξαγόρας μὲν οὖν φησι τὸν αἰθέρα πεφυκότα φέρεσθαι ἄνω, ἐμπίπτοντα δ' εἰς τὰ κάτω τῆς γῆς καὶ κοῖλα κινεῖν αὐτήν· τὰ μὲν γὰρ ἄνω συναλη-λεῖφθαι διὰ τοὺς ὄμβρους (ἐπεὶ φύσει γε ἅπασαν ὁμοίως εἶναι σομφήν), ὡς ὄντος τοῦ μὲν ἄνω τοῦ δὲ κάτω τῆς ὅλης σφαίρας, καὶ ἄνω μὲν τούτου

[1] Diels 56 A 1 (9), 42 (12), 89.

and Zephyros, beginning from north and ending farther south ; for people living in the east, they veer from the north to Apeliotes.

This completes our account of winds, their original genesis, their substance, and the attributes common to all and peculiar to each.

[1] seclusit O.T.

CHAPTER VII

ARGUMENT (*continued*)

Democritus (365 b 1-6), *and Anaximenes* (365 b 6-20) *are stated and criticized.*

We must next deal with earthquakes and earth tremors, a subject which follows naturally on our last, as the cause of these phenomena is akin to that of wind.

Three views :

Up to the present three theories have been put forward by three separate men. For Anaxagoras of Clazomenae and before him Anaximenes of Miletus both published views on the subject, and after them Democritus of Abdera.

Anaxagoras

Anaxagoras [a] says that the air, whose natural motion is upwards, causes earthquakes when it is trapped in hollows beneath the earth, which happens when the upper parts of the earth get clogged by rain, all earth being naturally porous. For he regards the globe [b] as having an upper and a lower part, the

[b] σφαῖρα presumably means the earth : but Anaxagoras thought the earth was flat : Diels 59 A 42 (3).

365 a
ὄντος τοῦ μορίου ἐφ' οὗ τυγχάνομεν οἰκοῦντες, κάτω δὲ θατέρου.

Πρὸς μὲν οὖν ταύτην τὴν αἰτίαν οὐδὲν ἴσως δεῖ λέγειν ὡς λίαν ἁπλῶς εἰρημένην· τό τε γὰρ ἄνω καὶ τὸ κάτω νομίζειν οὕτως ἔχειν ὥστε μὴ πρὸς μὲν τὴν γῆν πάντῃ φέρεσθαι τὰ βάρος ἔχοντα τῶν σωμάτων, ἄνω δὲ τὰ κοῦφα καὶ τὸ πῦρ, εὔηθες, καὶ ταῦθ' ὁρῶντας τὸν ὁρίζοντα τὴν οἰκουμένην ὅσην ἡμεῖς ἴσμεν, ἕτερον ἀεὶ γιγνόμενον μεθισταμένων, ὡς οὔσης κυρτῆς καὶ σφαιροειδοῦς· καὶ τὸ λέγειν μὲν ὡς διὰ τὸ μέγεθος ἐπὶ τοῦ ἀέρος μένειν, σείεσθαι δὲ φάσκειν τυπτομένην κάτωθεν ἄνω δι' ὅλης. πρὸς δὲ τούτοις οὐδὲν ἀποδίδωσι τῶν συμβαινόντων περὶ τοὺς σεισμούς· οὔτε γὰρ χῶραι οὔτε ὧραι αἱ τυχοῦσαι μετέχουσι τούτου τοῦ πάθους.

365 b Δημόκριτος δέ φησι πλήρη τὴν γῆν ὕδατος οὖσαν, καὶ πολὺ δεχομένην ἕτερον ὄμβριον ὕδωρ, ὑπὸ τούτου κινεῖσθαι· πλείονός τε γὰρ γιγνομένου διὰ τὸ μὴ δύνασθαι δέχεσθαι τὰς κοιλίας ἀποβιαζόμενον ποιεῖν τὸν σεισμόν, καὶ ξηραινομένην ἕλκουσαν εἰς τοὺς κενοὺς τόπους ἐκ τῶν πληρεστέρων τὸ μεταβάλλον ἐμπίπτον κινεῖν.

Ἀναξιμένης δέ φησιν βρεχομένην τὴν γῆν καὶ ξηραινομένην ῥήγνυσθαι, καὶ ὑπὸ τούτων τῶν ἀπορρηγνυμένων κολωνῶν ἐμπιπτόντων σείεσθαι· διὸ καὶ γίγνεσθαι τοὺς σεισμοὺς ἔν τε τοῖς αὐχμοῖς καὶ πάλιν ἐν ταῖς ἐπομβρίαις· ἔν τε γὰρ τοῖς αὐχμοῖς,

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[a] Aristotle is here criticizing Anaxagoras for a mistake of which he himself has often in turn been accused, that of

part on which we live being the upper part, the other the lower.

It is perhaps hardly necessary to say anything to refute this very elementary account. For it is very silly to think of up and down as if heavy bodies did not fall down to the earth from all directions and light ones (*e.g.* fire) rise up from it, especially when we see that throughout the known world the horizon always changes as we move, which indicates that we live on the convex surface of a sphere [a] It is silly, too, to think that the earth rests on the air because of its size, and that it is jarred right through by a shock from below. Besides, he fails to account for any of the peculiar features of earthquakes, which do not occur in any district or at any time indiscriminately.

Democritus [b] says the earth is full of water and that earthquakes are caused when a large amount of rain water falls besides this ; for when there is too much for the existing cavities in the earth to contain, it causes an earthquake by forcing its way out. Similarly, when the earth gets dried up water is drawn to the empty places from the fuller and causes earthquakes by the impact of its passage. Democritus;

Anaximenes [c] says that when the earth is in process of becoming wet or dry it breaks, and is shaken by the high ground breaking and falling. Which is why earthquakes occur in droughts and again in heavy rains : for in droughts the earth is dried and so, as Anaximenes.

supposing that up and down are absolute and not relative terms. The absoluteness in Aristotle's own use of the terms is due to his belief that the centre of the earth is the absolute centre of the universe

[b] Diels 68 A 97, 98.

[c] Diels 13 A 7 (8), 21.

365 b ὥσπερ εἴρηται, ξηραινομένην ῥήγνυσθαι, καὶ ὑπὸ τῶν ὑδάτων ὑπερυγραινομένην διαπίπτειν

Ἔδει δὲ τούτου συμβαίνοντος ὑπονοστοῦσαν πολλαχῇ φαίνεσθαι τὴν γῆν. ἔτι δὲ διὰ τίν' αἰτίαν περὶ τόπους τινὰς πολλάκις γίγνεται τοῦτο τὸ πάθος οὐδεμιᾷ διαφέροντας ὑπερβολῇ τοιαύτῃ παρὰ τοὺς ἄλλους; καίτοι ἐχρῆν. ὅλως δὲ τοῖς οὕτως ὑπολαμβάνουσιν ἀναγκαῖον ἧττον ἀεὶ τοὺς σεισμοὺς φάναι γίγνεσθαι, καὶ τέλος παύσασθαί ποτε σειομένην· τὸ γὰρ σαττόμενον τοιαύτην ἔχει φύσιν. ὥστ' εἰ τοῦτ' ἀδύνατον, δῆλον ὅτι ἀδύνατον καὶ ταύτην εἶναι τὴν αἰτίαν.

CHAPTER VIII

ARGUMENT

Earthquakes (continued). The cause of earthquakes is wind (i.e. *dry exhalation*) *when it gets trapped in the earth* (365 b 21—366 a 5). *So most earthquakes occur in calm weather, having exhausted all the available wind · if an earthquake is accompanied by a wind it is likely to be less violent as the motive cause is divided* (366 a 5-23). *Earthquakes are severest in places where the earth is hollow* (366 a 23–b 1); *and most frequent in spring and autumn and during rains and droughts, since exhalation is produced in the greatest quantities at these times* (366 b 1-14). *Analogies from the human body and confirmatory examples* (366 b 14—367 a 20). *Various concomitants and signs of earthquakes all confirm our theory* (367 a 20–b 19). *Earthquakes and eclipses* (367 b 19-33). *After a severe earthquake the shocks may last for some time* (367 b 33—368 a 14). *Wind the cause of subterranean noises* (368 a 14-25). *Earthquakes are sometimes accompanied by an outbreak of water . but their cause is*

just explained, breaks, and when the rains make it excessively wet it falls apart

But (i) if this is so the earth ought to be sinking obviously in many places, (ii) and why do earthquakes occur often in some places which, compared with others, are by no means conspicuous for any such excess of drought or rain, as on this theory they should be? (iii) Besides, on this theory it must be maintained that earthquakes are getting progressively fewer, and will some day cease altogether. For this would be the natural result of the packing down process it describes. But if this is impossible, then this account of their cause must be impossible too.

CHAPTER VIII

ARGUMENT (*continued*)

nevertheless air (368 a 26–33). *Why tidal waves accompany earthquakes* (368 a 33–b 12). *Why earthquakes are confined to one locality, while winds are more general* (368 b 12–22). *Two types of earthquake shock* (368 b 22–32). *Earthquakes rare in islands at a distance from the mainland* (368 b 32–369 a 7). *Conclusion* (369 a 7–9).

Note.—*In this chapter the word normally translated "wind" is* πνεῦμα *: but on occasion* ἄνεμος *is used as an alternative, and twice, apparently,* ἀήρ (367 a 11, 20). *More strictly,* ἀήρ *is atmospheric air, a combination of the dry and moist exhalations.* πνεῦμα *and* ἄνεμος, *both translated "wind," and both composed of dry exhalation, are closely similar : but* ἄνεμος *is the narrower term, meaning wind in the strict sense, whereas* πνεῦμα, *both in this and the following chapters (*ii. 8, 9, iii. 1*), is used in a wider sense to mean the dry exhalation in so far as it is the material which manifests itself not only in wind in the strict sense, but in earthquakes,*

thunder, lightning, etc. With the parallel with the human body drawn in 366 b 14 *ff compare Shakespeare,* Henry IV, *Pt. I. III. i :*

> Diseased nature oftentimes breaks forth
> In strange eruptions ; oft the teeming earth

365 b 21 Ἀλλ' ἐπειδὴ φανερὸν ὅτι ἀναγκαῖον καὶ ἀπὸ ὑγροῦ καὶ ἀπὸ ξηροῦ γίγνεσθαι ἀναθυμίασιν, ὥσπερ εἴπομεν ἐν τοῖς πρότερον, ἀνάγκη τούτων ὑπαρχόντων γίγνεσθαι τοὺς σεισμούς. ὑπάρχει γὰρ ἡ γῆ καθ' αὑτὴν μὲν ξηρά, διὰ δὲ τοὺς ὄμβρους ἔχουσα ἐν αὑτῇ νοτίδα πολλήν, ὥσθ' ὑπό τε τοῦ ἡλίου καὶ τοῦ ἐν αὐτῇ πυρὸς θερμαινομένης πολὺ μὲν ἔξω πολὺ δ' ἐντὸς γίγνεσθαι τὸ πνεῦμα· καὶ τοῦτο ὁτὲ μὲν συνεχὲς ἔξω ῥεῖ πᾶν, ὁτὲ δ' εἴσω πᾶν, ἐνίοτε δὲ καὶ μερίζεται.

Εἰ δὴ τοῦτ' ἀδύνατον ἄλλως ἔχειν, τὸ μετὰ τοῦτο σκεπτέον ἂν εἴη ποῖον κινητικώτατον εἴη τῶν σωμάτων ἀνάγκη γὰρ τὸ ἐπὶ πλεῖστόν τε πεφυκὸς ἰέναι καὶ σφοδρότατον μάλιστα τοιοῦτον εἶναι. σφοδρότατον μὲν οὖν ἐξ ἀνάγκης τὸ τάχιστα φερόμενον· πλήσσει γὰρ μάλιστα διὰ τὸ τάχος· ἐπὶ πλεῖστον δὲ πέφυκε διιέναι τὸ διὰ παντὸς ἰέναι μάλιστα δυνάμενον, τοιοῦτον δὲ τὸ λεπτότατον. 366 a ὥστ' εἴπερ ἡ τοῦ πνεύματος φύσις τοιαύτη, μάλιστα τῶν σωμάτων τὸ πνεῦμα κινητικόν· καὶ γὰρ τὸ πῦρ ὅταν μετὰ πνεύματος ᾖ, γίγνεται φλὸξ καὶ φέρεται ταχέως. οὐκ ἂν οὖν ὕδωρ οὐδὲ γῆ αἴτιον εἴη, ἀλλὰ πνεῦμα τῆς κινήσεως, ὅταν εἴσω τύχῃ ῥυὲν τὸ ἔξω ἀναθυμιώμενον.

Διὸ γίγνονται νηνεμίας οἱ πλεῖστοι καὶ μέγιστοι τῶν σεισμῶν· συνεχὴς γὰρ οὖσα ἡ ἀναθυμίασις

Is with a kind of colic pinch'd and vex'd
By the imprisoning of unruly wind
Within her womb, which, for enlargement striving,
Shakes the old beldam earth, and topples down
Steeples and moss-grown towers.

Now it is clear, as we have already said,[a] that there must be exhalation both from moist and dry, and earthquakes are a necessary result of the existence of these exhalations. For the earth is in itself dry but contains much moisture because of the rain that falls on it; with the result that when it is heated by the sun and its own internal fire, a considerable amount of wind is generated both outside it and inside, and this sometimes all flows out, sometimes all flows in, while sometimes it is split up.

The cause of earthquakes is wind, produced by exhalation

This process is inevitable. Our next step should therefore be to consider what substance has the greatest motive power. This must necessarily be the substance whose natural motion is most prolonged and whose action is most violent. The substance most violent in action must be that which has the greatest velocity, as its velocity makes its impact most forcible. The farthest mover must be the most penetrating, that is, the finest. If, therefore, the natural constitution of wind is of this kind, it must be the substance whose motive power is the greatest. For even fire when conjoined with wind is blown to flame and moves quickly. So the cause of earth tremors is neither water nor earth but wind, which causes them when the external exhalation flows inwards.

This is why the majority of earthquakes and the greatest occur in calm weather. For the exhalation

Earthquakes commonest in calm weather

[a] Book I. ch. 4, 341 b 6.

366 a ἀκολουθεῖ ὡς ἐπὶ τὸ πολὺ τῇ ὁρμῇ τῆς ἀρχῆς, ὥστε ἢ ἔσω ἅμα ἢ ἔξω ὁρμᾷ πᾶσα. τὸ δ' ἐνίους γίγνεσθαι καὶ πνεύματος ὄντος οὐδὲν ἄλογον· ὁρῶμεν γὰρ ἐνίοτε ἅμα πλείους πνέοντας ἀνέμους, ὧν ὅταν εἰς τὴν γῆν ὁρμήσῃ θάτερον, ἔσται πνεύματος ὄντος ὁ σεισμός. ἐλάττους δ' οὗτοι τὸ μέγεθος γίγνονται διὰ τὸ διῃρῆσθαι τὴν ἀρχὴν καὶ τὴν αἰτίαν αὐτῶν. νυκτὸς δ' οἱ πλείους καὶ μείζους γίγνονται τῶν σεισμῶν, οἱ δὲ τῆς ἡμέρας περὶ μεσημβρίαν· νηνεμώτατον γάρ ἐστιν ὡς ἐπὶ τὸ πολὺ τῆς ἡμέρας ἡ μεσημβρία (ὁ γὰρ ἥλιος ὅταν μάλιστα κρατῇ, κατακλείει τὴν ἀναθυμίασιν εἰς τὴν γῆν· κρατεῖ δὲ μάλιστα περὶ τὴν μεσημβρίαν), καὶ αἱ νύκτες δὲ τῶν ἡμερῶν νηνεμώτεραι διὰ τὴν ἀπουσίαν τὴν τοῦ ἡλίου· ὥστ' ἔσω γίγνεται πάλιν ἡ ῥύσις, ὥσπερ ἄμπωτις, εἰς τοὐναντίον τῆς ἔξω πλημμυρίδος, καὶ πρὸς ὄρθρον μάλιστα· τηνικαῦτα γὰρ καὶ τὰ πνεύματα πέφυκεν ἄρχεσθαι πνεῖν. ἐὰν οὖν εἴσω τύχῃ μεταβάλλουσα ἡ ἀρχὴ αὐτῶν ὥσπερ Εὔριπος, διὰ τὸ πλῆθος ἰσχυρότερον ποιεῖ τὸν σεισμόν.

Ἔτι δὲ περὶ τόπους τοιούτους οἱ ἰσχυρότατοι γίγνονται τῶν σεισμῶν, ὅπου θάλαττα ῥοώδης ἢ ἡ χώρα σομφὴ καὶ ὕπαντρος· διὸ καὶ περὶ Ἑλλήσποντον καὶ περὶ Ἀχαΐαν καὶ Σικελίαν, καὶ τῆς Εὐβοίας περὶ τούτους τοὺς τόπους· δοκεῖ γὰρ διαυλωνίζειν ὑπὸ τὴν γῆν ἡ θάλαττα· διὸ καὶ τὰ θερμὰ τὰ περὶ Αἰδηψὸν ἀπὸ τοιαύτης αἰτίας γέγονε. περὶ δὲ τοὺς εἰρημένους τόπους οἱ σεισμοὶ γίγνονται μάλιστα διὰ τὴν στενότητα· τὸ γὰρ πνεῦμα γιγνόμενον σφοδρὸν καὶ διὰ τὸ πλῆθος τῆς θαλάττης πολλῆς προσφερομένης ἀπωθεῖται πάλιν εἰς τὴν

being continuous in general follows its initial impulse and tends either all to flow inwards at once or all outwards. There is, however, nothing inexplicable in the fact that some earthquakes occur when a wind is blowing; for we sometimes see several winds blowing at the same time, and when one of these plunges into the earth the resultant earthquake is accompanied by wind. But these earthquakes are less violent, because the energy of their original cause is divided Most major earthquakes occur at night, and those that occur in daytime at midday, this being as a rule the calmest time of day, because when the sun is at its strongest it confines the exhalation within the earth, and it is at its strongest about midday; and the night again is calmer than the day because of the sun's absence. So at these times the flow turns inwards again, like an ebb as opposed to the outward flood. This happens especially towards dawn, for it is then that winds normally begin to blow. If, then, the original impulse of the exhalation changes direction, like the Euripus, and turns inwards, it causes a more violent earthquake because of its quantity.

Where earthquakes are severest.

Again, the severest earthquakes occur in places where the sea is full of currents or the earth is porous and hollow. So they occur in the Hellespont and Achaea and Sicily, and in the districts in Euboea where the sea is supposed to run in channels beneath the earth. The hot springs at Aedepsus [a] are due to a similar cause. In the places mentioned earthquakes occur mostly because of the constricted space. For when a violent wind arises the volume of the inflowing sea drives it back into the earth, when it would

[a] In Euboea.

366 a γῆν, τὸ πεφυκὸς ἀποπνεῖν ἐκ τῆς γῆς αἵ τε χῶραι
366 b ὅσαι σομφοὺς ἔχουσι τοὺς κάτω τόπους, πολὺ δεχόμεναι πνεῦμα σείονται μᾶλλον.

Καὶ ἔαρος δὲ καὶ μετοπώρου μάλιστα καὶ ἐν ἐπομβρίαις καὶ ἐν αὐχμοῖς γίγνονται διὰ τὴν αὐτὴν αἰτίαν· αἵ τε γὰρ ὧραι αὗται πνευματωδέσταται· τὸ γὰρ θέρος καὶ ὁ χειμών, τὸ μὲν διὰ τὸν πάγον, τὸ δὲ διὰ τὴν ἀλέαν ποιεῖ τὴν ἀκινησίαν· τὸ μὲν γὰρ ἄγαν ψυχρόν, τὸ δ' ἄγαν ξηρόν ἐστι· καὶ ἐν μὲν τοῖς αὐχμοῖς πνευματώδης ὁ ἀήρ· τοῦτο γὰρ αὐτό ἐστιν ὁ αὐχμός, ὅταν πλείων ἡ ἀναθυμίασις ἡ ξηρὰ γίγνηται τῆς ὑγρᾶς· ἐν δὲ ταῖς ὑπερομβρίαις πλείω τε ποιεῖ τὴν ἐντὸς ἀναθυμίασιν, καὶ τῷ ἐναπολαμβάνεσθαι ἐν στενοτέροις τόποις καὶ ἀποβιάζεσθαι εἰς ἐλάττω τόπον τὴν τοιαύτην ἀπόκρισιν, πληρουμένων τῶν κοιλιῶν ὕδατος, ὅταν ἄρξηται κρατεῖν διὰ τὸ πολὺ εἰς ὀλίγον πιληθῆναι τόπον, ἰσχυρῶς κινεῖ ῥέων ὁ ἄνεμος καὶ προσπίπτων· δεῖ γὰρ νοεῖν ὅτι ὥσπερ ἐν τῷ σώματι ἡμῶν καὶ τρόμων καὶ σφυγμῶν αἴτιόν ἐστιν ἡ τοῦ πνεύματος ἐναπολαμβανομένη δύναμις, οὕτω καὶ ἐν τῇ γῇ τὸ πνεῦμα παραπλήσιον ποιεῖν, καὶ τὸν μὲν τῶν σεισμῶν οἷον τρόμον εἶναι τὸν δ' οἷον σφυγμόν, καὶ καθάπερ συμβαίνει πολλάκις μετὰ τὴν οὔρησιν (διὰ τοῦ σώματος γὰρ γίγνεται ὥσπερ τρόμος τις ἀντιμεθισταμένου τοῦ πνεύματος ἔξωθεν εἴσω ἀθρόου), τοιαῦτα [γὰρ][1] γίγνεσθαι καὶ περὶ τὴν γῆν. ὅσην δ' ἔχει τὸ πνεῦμα δύναμιν, οὐ μόνον ἐκ τῶν ἐν τῷ ἀέρι δεῖ θεωρεῖν γιγνομένων (ἐνταῦθα μὲν γὰρ διὰ τὸ μέγεθος ὑπολάβοι τις ἂν τοιαῦτα δύνασθαι ποιεῖν) ἀλλὰ καὶ ἐν τοῖς σώμασι τοῖς τῶν ζῴων· οἵ τε γὰρ τέτανοι καὶ οἱ σπασμοὶ πνεύματος μέν

naturally be exhaled from it. And places whose subsoil is porous are shaken more because of the large amount of wind they absorb.

When earthquakes are most frequent.

For the same reason earthquakes occur most often in spring and autumn and during rains and droughts, since these periods produce most wind. For summer and winter both bring calm weather, the one because of its frosts, the other because of its warmth, the one thus being too cold, the other being too dry to produce winds. But in times of drought the air is full of wind, drought simply being an excess of dry over moist exhalation. In times of rain the exhalation is produced within the earth in greater quantity,[a] and when what has been so produced is caught in a constricted space and forcibly compressed as the hollows within the earth fill with water, the impact of the stream of the wind on the earth causes a severe shock, once the compression of a large quantity of it into a small space begins to have its effect. For we must suppose that the wind in the earth has effects similar to those of the wind in our bodies whose force when it is pent up inside us can cause tremors and throbbings, some earthquakes being like a tremor, some like a throbbing. We must suppose, again, that the earth is affected as we often are after making water, when a sort of tremor runs through the body as a body of wind turns inwards again from without.[b] For the force that wind has can be seen not only by studying its effects in the air, when one would expect it to be able to produce them because of its volume, but also in the bodies of living things. Tetanus and spasms

Analogies from the human body

[a] *Cf.* 361 a 17.

[b] *Cf. Problems* VIII. 8, 13, XXXIII. 16.

[1] γὰρ seclusit Fobes.

366 b εἰσιν κινήσεις, τοσαύτην δὲ ἔχουσιν ἰσχὺν ὥστε πολλοὺς ἅμα πειρωμένους ἀποβιάζεσθαι μὴ δύνασθαι κρατεῖν τῆς κινήσεως τῶν ἀρρωστούντων. τοιοῦτον δὴ δεῖ νοεῖν τὸ γιγνόμενον καὶ ἐν τῇ γῇ, ὡς εἰκάσαι πρὸς μικρὸν μεῖζον.

Σημεῖα δὲ τούτων καὶ πρὸς τὴν ἡμετέραν αἴσθησιν πολλαχῇ γέγονεν· ἤδη γὰρ σεισμὸς ἐν τόποις τισὶν γιγνόμενος οὐ πρότερον ἔληξε πρὶν ἐκρήξας εἰς τὸν ὑπὲρ τῆς γῆς τόπον φανερῶς ὥσπερ ἐκ-
367 a νεφίας ἐξῆλθεν ὁ κινήσας ἄνεμος, οἷον καὶ περὶ Ἡράκλειαν ἐγένετο τὴν ἐν τῷ Πόντῳ νεωστί, καὶ πρότερον περὶ τὴν Ἱερὰν νῆσον (αὕτη δ' ἐστὶν μία τῶν Αἰόλου καλουμένων νήσων)· ἐν ταύτῃ γὰρ ἀνῴδει τι τῆς γῆς, καὶ ἀνῄει οἷον λοφώδης ὄγκος
5 μετὰ ψόφου· τέλος δὲ ῥαγέντος ἐξῆλθεν πνεῦμα πολὺ καὶ τὸν φέψαλον καὶ τὴν τέφραν ἀνῆκεν καὶ τήν τε Λιπαραίων πόλιν οὖσαν οὐ πόρρω πᾶσαν κατετέφρωσε καὶ εἰς ἐνίας τῶν ἐν Ἰταλίᾳ πόλεων ἦλθεν· καὶ νῦν ὅπου τὸ ἀναφύσημα τοῦτο ἐγένετο, δῆλόν ἐστιν. καὶ γὰρ δὴ τοῦ γιγνομένου πυρὸς
10 ἐν τῇ γῇ ταύτην οἰητέον εἶναι τὴν αἰτίαν, ὅταν κοπτόμενον ἐκπρησθῇ πρῶτον εἰς μικρὰ κερματισθέντος τοῦ ἀέρος.

Τεκμήριον δ' ἐστὶ τοῦ ῥεῖν ὑπὸ γῆν τὰ πνεύματα καὶ τὸ γιγνόμενον περὶ ταύτας τὰς νήσους· ὅταν γὰρ ἄνεμος μέλλῃ πνευσεῖσθαι νότος, προσημαίνει πρότερον· ἠχοῦσι γὰρ οἱ τόποι ἐξ ὧν γίγνεται τὰ
15 ἀναφυσήματα, διὰ τὸ τὴν θάλατταν μὲν προωθεῖσθαι ἤδη πόρρωθεν, ὑπὸ δὲ ταύτης τὸ ἐκ τῆς γῆς ἀναφυσώμενον ἀπωθεῖσθαι πάλιν εἴσω, ἥπερ ἐπέρχεται ἡ θάλαττα ταύτῃ. ποιεῖ δὲ ψόφον ἄνευ σεισμοῦ

are movements caused by wind, and are so strong that the combined strength and efforts of a number of men is unable to master the movements of their victims. And if we may compare great things with small, we must suppose that the same sort of thing happens to the earth.

As evidence we may cite occurrences which have been observed in many places. For in some places there has been an earthquake which has not ceased until the wind which was its motive force has broken out like a hurricane and risen into the upper region. This happened recently, for instance, in Heracleia in Pontus, and before that in Hiera, one of the so-called Aeolian islands. For in this island part of the earth swelled up and rose with a noise in a crest-shaped lump; this finally exploded and a large quantity of wind broke out, blowing up cinders and ash which smothered the neighbouring city of Lipara, and even reached as far as some of the cities in Italy The place where this eruption took place can still be seen. (This too must be regarded as the cause of the fire that there is in the earth; for when the air is broken up into small particles, percussion then causes it to catch fire) [a] Confirmatory examples.

And there is a proof that winds circulate beneath the earth in something else that happens in these islands. For when a south wind is going to blow it is heralded by noises from the places from which eruptions occur. This is because the sea, which is being driven forward from far off, thrusts the wind that is erupting out of the earth back again when it meets it. This causes a noise but no earthquake

[a] The warm and dry (and so inflammable) exhalation is one of the constituents of air.

367 a διά τε τὴν εὐρυχωρίαν τῶν τόπων (ὑπερχεῖται γὰρ
20 εἰς τὸ ἀχανὲς ἔξω) καὶ δι' ὀλιγότητα τοῦ ἀπωθουμένου ἀέρος.

Ἔτι τὸ γίγνεσθαι τὸν ἥλιον ἀχλυώδη καὶ ἀμαυρότερον ἄνευ νέφους, καὶ πρὸ τῶν ὀρθρίων σεισμῶν ἐνίοτε νηνεμίαν τε καὶ κρύος ἰσχυρόν, σημεῖον τῆς εἰρημένης αἰτίας ἐστίν. τόν τε γὰρ ἥλιον ἀχλυώδη καὶ ἀμαυρὸν ἀναγκαῖον εἶναι ὑπονοστεῖν ἀρχομένου
25 τοῦ πνεύματος εἰς τὴν γῆν τοῦ διαλύοντος τὸν ἀέρα καὶ διακρίνοντος, καὶ πρὸς τὴν ἕω καὶ περὶ τοὺς ὄρθρους νηνεμίαν τε καὶ ψῦχος. τὴν μὲν γὰρ νηνεμίαν ἀναγκαῖον ὡς ἐπὶ τὸ πολὺ συμβαίνειν, καθάπερ εἴρηται καὶ πρότερον, οἷον μεταρροίας εἴσω γιγνομένης τοῦ πνεύματος, καὶ μᾶλλον πρὸ τῶν
30 μειζόνων σεισμῶν· μὴ διασπώμενον γὰρ τὸ μὲν ἔξω τὸ δ' ἐντός, ἀλλ' ἀθρόως φερόμενον ἀναγκαῖον ἰσχύειν μᾶλλον. τὸ δὲ ψῦχος συμβαίνει διὰ τὸ τὴν ἀναθυμίασιν εἴσω τρέπεσθαι, φύσει θερμὴν οὖσαν καθ' αὑτήν. οὐ δοκοῦσι δ' οἱ ἄνεμοι εἶναι θερμοὶ διὰ τὸ κινεῖν τὸν ἀέρα πλήρη πολλῆς ὄντα
367 b καὶ ψυχρᾶς ἀτμίδος, ὥσπερ τὸ πνεῦμα ⟨τὸ⟩ διὰ τοῦ στόματος φυσώμενον· καὶ γὰρ τοῦτο ἐγγύθεν μέν ἐστι θερμόν, ὥσπερ καὶ ὅταν ἀάζωμεν, ἀλλὰ δι' ὀλιγότητα οὐχ ὁμοίως ἐπίδηλον, πόρρωθεν δὲ ψυχρὸν διὰ τὴν αὐτὴν αἰτίαν τοῖς ἀνέμοις. ἐκ-
5 λειπούσης οὖν εἰς τὴν γῆν τῆς τοιαύτης δυνάμεως, συνιοῦσα δι' ὑγρότητα[1] ἡ ἀτμιδώδης ἀπόρροια ποιεῖ τὸ ψῦχος, ἐν οἷς συμβαίνει τόποις γίγνεσθαι τοῦτο τὸ πάθος. τὸ δ' αὐτὸ αἴτιον καὶ τοῦ εἰωθότος ἐνίοτε γίγνεσθαι σημείου πρὸ τῶν σεισμῶν. ἢ γὰρ

because there is plenty of room for the wind, of which there is only a small quantity and which can overflow into the void outside

Further evidence that our account of the cause of earthquakes is correct is afforded by the facts that before them the sun becomes misty and dimmer though there is no cloud, and that before earthquakes that occur at dawn there is often a calm and a hard frost The sun is necessarily misty and dim when the wind which dissolves and breaks up the air begins to retreat into the earth Calm and cold towards sunrise and dawn are also necessary concomitants. Calm must usually fall, as we have explained,[a] because the wind drains back as it were into the earth, and the greater the earthquake the more this happens ; for the earthquake is bound to be more severe if the wind is not dispersed, some outside and some in, but moves in a mass. The reason for the cold is that the exhalation, which is by nature essentially warm, is directed inwards. (Winds are not usually supposed to be warm because they set the air in motion and the air contains large quantities of cold vapour This can be seen when wind is blown out of the mouth close by it is warm, as when we breathe with open mouth, though there is too little of it to be very noticeable, while farther off it is cool for the same reason as the winds.) So the warm element disappears into the earth, and wherever this happens, the vaporous exhalation being moist condenses and causes cold . The cause of a sign which often heralds earthquakes is the same. In clear weather, either

Further confirmatory evidence.

[a] 366 a 5 ff.

[1] δι' ὑγρότητα om. O.T.

367 b μεθ' ἡμέραν ἢ μικρὸν μετὰ δυσμάς, αἰθρίας οὔσης,
νεφέλιον λεπτὸν φαίνεται διατεῖνον καὶ μακρόν,
οἷον γραμμῆς μῆκος εὐθύτητι διηκριβωμένον, τοῦ
πνεύματος ἀπομαραινομένου διὰ τὴν μετάστασιν.
τὸ δ' ὅμοιον συμβαίνει καὶ ἐν τῇ θαλάττῃ περὶ τοὺς
αἰγιαλούς· ὅταν μὲν γὰρ κυμαίνουσα ἐκβάλλῃ, σφό-
δρα παχεῖαι καὶ σκολιαὶ γίγνονται αἱ ῥηγμῖνες,
ὅταν δὲ γαλήνη ᾖ, [διὰ τὸ μικρὰν ποιεῖσθαι τὴν
ἔκκρισιν][1] λεπταί εἰσι καὶ εὐθεῖαι. ὅπερ οὖν ἡ
θάλαττα ποιεῖ περὶ τὴν γῆν, τοῦτο τὸ πνεῦμα περὶ
τὴν ἐν τῷ ἀέρι ἀχλύν, ὥσθ' ὅταν γένηται νηνεμία,
πάμπαν εὐθεῖαν καὶ λεπτὴν καταλείπεσθαι ὥσπερ
ῥηγμῖνα οὖσαν ἀέρος τὴν νεφέλην.

Διὰ ταῦτα δὲ καὶ περὶ τὰς ἐκλείψεις ἐνίοτε τῆς
σελήνης συμβαίνει γίγνεσθαι σεισμόν· ὅταν γὰρ
ἤδη πλησίον ᾖ ἡ ἀντίφραξις, καὶ μήπω μὲν ᾖ
πάμπαν ἀπολελοιπὸς τὸ φῶς καὶ τὸ ἀπὸ τοῦ ἡλίου
θερμὸν ἐκ τοῦ ἀέρος, ἤδη δ' ἀπομαραινόμενον,
νηνεμία γίγνεται ἀντιμεθισταμένου τοῦ πνεύματος
εἰς τὴν γῆν, ὃ ποιεῖ τὸν σεισμὸν πρὸ τῶν ἐκλεί-
ψεων. γίγνονται γὰρ καὶ ἄνεμοι πρὸ τῶν ἐκλείψεων
πολλάκις, ἀκρόνυχον μὲν πρὸ τῶν μεσονυκτίων
ἐκλείψεων, μεσονύκτιον δὲ πρὸ τῶν ἑῴων. συμ-
βαίνει δὲ τοῦτο διὰ τὸ ἀμαυροῦσθαι τὸ θερμὸν τὸ
ἀπὸ τῆς σελήνης, ὅταν πλησίον ἤδη γίγνηται ἡ
φορὰ ἐν ᾧ γενομένων ἔσται ἡ ἔκλειψις. ἀνιεμένου
οὖν ᾧ κατείχετο ὁ ἀὴρ καὶ ἠρέμει, πάλιν κινεῖται
καὶ γίγνεται πνεῦμα τῆς ὀψιαίτερον ἐκλείψεως
ὀψιαίτερον.

[a]Ὅταν δ' ἰσχυρὸς γένηται σεισμός, οὐκ εὐθὺς οὐδ'

[1] διὰ . . . ἔκκρισιν seclusit O.T.

[a] Into the earth, *cf.* 367 a 26.

by day or a little after sunset, a fine long streak of cloud appears, like a long straight line carefully drawn, the reason being that the wind is dying down and running away.[a] Something like it happens on the seashore too For when the sea runs high the breakers are large and uneven, but when there is a calm they are fine and straight [because the amount of exhalation is small].[b] The wind produces the same effects on the cloud in the sky as the sea on the shore, so that when there is a calm the clouds that are left are all straight and fine like breakers in the air.

Earthquakes and eclipses.

For the same reason an earthquake sometimes occurs at an eclipse of the moon. For when the interposition is approaching but the light and warmth from the sun,[c] though already fading, have not entirely disappeared from the air, a calm falls when the wind runs back into the earth. And this causes the earthquake before the eclipse. For there are often winds also before eclipses, at nightfall before a midnight eclipse, at midnight before an eclipse at dawn. The reason for this is the failure of the heat from the moon when its course approaches the point at which[d] the eclipse will take place. Thus when the cause which held it quiet ceases to operate the air is set in motion again and a wind rises, and the later the eclipse, the later this happens.[e]

Shocks continue after a severe earthquake.

When an earthquake is severe the shocks do not

[b] The O.T. omits these words as "a misguided gloss on γαλήνη." Alex. shows no sign of having had them in his text.

[c] Reflected from the moon (Alex.).

[d] "Lit. 'at which, when the moon and its sphere (φορά) have got there'" (O.T.)

[e] With this somewhat obscure paragraph *cf. Problems* xxvi. 18, 942 a 22.

367 b εἰσάπαξ παύεται σείσας, ἀλλὰ τὸ πρῶτον μὲν μέχρι περὶ τετταράκοντα πρόεισι πολλάκις ἡμέρας, ὕστε-
368 a ρον δὲ καὶ ἐφ' ἓν καὶ ἐπὶ δύο ἔτη ἐπισημαίνει κατὰ τοὺς αὐτοὺς τόπους. αἴτιον δὲ τοῦ μὲν μεγέθους τὸ πλῆθος τοῦ πνεύματος καὶ τῶν τόπων τὰ σχήματα δι' οἵων ἂν ῥυῇ ᾗ γὰρ ἂν ἀντιτυπήσῃ καὶ μὴ ῥᾳδίως διέλθῃ, μάλιστά τε σείει καὶ ἐγκαταλεί-
5 πεσθαι ἀναγκαῖον ἐν ταῖς δυσχωρίαις, οἷον ὕδωρ ἐν σκεύει οὐ δυνάμενον διεξελθεῖν. διὸ καθάπερ ἐν σώματι οἱ σφυγμοὶ οὐκ ἐξαίφνης παύονται οὐδὲ ταχέως, ἀλλ' ἐκ προσαγωγῆς ἅμα καταμαραινομένου τοῦ πάθους, καὶ ἡ ἀρχὴ ἀφ' ἧς ἡ ἀναθυμίασις ἐγένετο καὶ ἡ ὁρμὴ τοῦ πνεύματος δῆλον ὅτι οὐκ
10 εὐθὺς ἅπασαν ἀνήλωσεν τὴν ὕλην, ἐξ ἧς ἐποίησε τὸν ἄνεμον, ὃν καλοῦμεν σεισμόν. ἕως ἂν οὖν ἀναλωθῇ τὰ ὑπόλοιπα τούτων, ἀνάγκη σείειν, ἠρεμαιότερον δὲ καὶ μέχρι τούτου ἕως ἂν ἔλαττον ᾖ τὸ ἀναθυμίωμενον ἢ ὥστε δύνασθαι κινεῖν ἐπιδήλως.

15 Ποιεῖ δὲ καὶ τοὺς ψόφους τοὺς ὑπὸ τὴν γῆν γιγνομένους τὸ πνεῦμα, καὶ τοὺς πρὸ τῶν σεισμῶν· καὶ ἄνευ δὲ σεισμῶν ἤδη που γεγόνασιν ὑπὸ γῆν· ὥσπερ γὰρ καὶ ῥαπιζόμενος ὁ ἀὴρ παντοδαποὺς ἀφίησι ψόφους, οὕτως καὶ τύπτων αὐτός· οὐδὲν γὰρ διαφέρει· τὸ γὰρ τύπτον ἅμα καὶ αὐτὸ τύπτεται
20 πᾶν. προέρχεται δὲ ὁ ψόφος τῆς κινήσεως διὰ τὸ λεπτομερέστερον εἶναι καὶ μᾶλλον διὰ παντὸς ἰέναι τοῦ πνεύματος τὸν ψόφον. ὅταν δ' ἔλαττον ᾖ ἢ ὥστε κινῆσαι τὴν γῆν διὰ λεπτότητα, διὰ μὲν τὸ ῥᾳδίως διηθεῖσθαι οὐ δύναται κινεῖν, διὰ δὲ τὸ προσπίπτειν στερεοῖς ὄγκοις καὶ κοίλοις καὶ παντοδαποῖς σχήμασι παντοδαπὴν ἀφίησι φωνήν, ὥστ'

cease immediately or at once, but frequently go on for forty days or so in the first instance, and symptoms appear subsequently for one or two years in the same district The cause of the severity is the amount of the wind and the shape of the passages through which it has to flow. When it meets with resistance and cannot easily get through, the shocks are severest and air is bound to be left in the narrow places, like water that cannot get out of a vessel. Therefore, just as throbbings in the body do not stop at once or quickly, but gradually as the affliction which is their cause dies away, so the originating cause of the exhalation and the source of the wind clearly do not expend all at once the material which produces the wind which we call an earthquake. Until, therefore, the rest of it is expended shocks must continue, their force decreasing until there is too little exhalation to cause a shock that is noticeable.

Wind is also the cause of noises beneath the earth, among them the noises that precede earthquakes, though they have also been known to occur without an earthquake following. For as the air when struck gives out all sorts of noises, so also it does when it is itself the striker ; the effect is the same in either case, since every striker is itself also struck. The sound precedes the shock because the sound is of finer texture and so more penetrating than the wind itself When the wind is too fine to communicate any impulse to the earth, being unable to do so because of the ease with which it filters through it, nevertheless when it strikes hard or hollow masses of all shapes it gives out all sorts of noises, so that sometimes the

Wind the cause of subterranean noises.

368 a
ἐνίοτε δοκεῖν ὅπερ λέγουσιν οἱ τερατολογοῦντες, μυκᾶσθαι τὴν γῆν.

Ἤδη δὲ καὶ ὕδατα ἀνερράγη γιγνομένων σεισμῶν· ἀλλ' οὐ διὰ τοῦτο αἴτιον τὸ ὕδωρ τῆς κινήσεως, ἀλλ' ἂν ᾖ ἐξ ἐπιπολῆς ἢ κάτωθεν βιάζηται τὸ πνεῦμα, ἐκεῖνο τὸ κινοῦν ἐστιν, ὥσπερ τῶν κυμάτων οἱ ἄνεμοι ἀλλ' οὐ τὰ κύματα τῶν ἀνέμων εἰσὶν αἴτια, ἐπεὶ καὶ τὴν γῆν οὕτως ἄν τις αἰτιῷτο τοῦ πάθους· ἀνατρέπεται γὰρ σειομένη, καθάπερ ὕδωρ (ἡ γὰρ ἔκχυσις ἀνάτρεψίς τίς ἐστιν). ἀλλ' αἴτια ταῦτα μὲν ἄμφω ὡς ὕλη (πάσχει γάρ, ἀλλ' οὐ ποιεῖ), τὸ δὲ πνεῦμα ὡς ἀρχή.

Ὅπου δ' ἅμα κῦμα σεισμῷ γέγονεν, αἴτιον, ὅταν ἐναντία γίγνηται τὰ πνεύματα. τοῦτο δὲ γίγνεται
368 b ὅταν τὸ σεῖον τὴν γῆν πνεῦμα φερομένην ὑπ' ἄλλου πνεύματος τὴν θάλατταν ἀπῶσαι μὲν ὅλως μὴ δύνηται, προωθοῦν δὲ καὶ συστέλλον εἰς ταὐτὸν συναθροίσῃ πολλήν· τότε γὰρ ἀναγκαῖον ἠττηθέντος τούτου τοῦ πνεύματος ἀθρόαν ὠθουμένην ὑπὸ τοῦ ἐναντίου πνεύματος ἐκρήγνυσθαι καὶ ποιεῖν τὸν κατακλυσμόν. ἐγένετο δὲ τοῦτο καὶ περὶ Ἀχαΐαν· ἐκεῖ[1] μὲν γὰρ ἦν νότος, ἔξω[1] δὲ βορέας, νηνεμίας δὲ γενομένης καὶ ῥυέντος εἴσω τοῦ ἀνέμου ἐγένετο τό τε κῦμα καὶ ὁ σεισμὸς ἅμα, καὶ μᾶλλον διὰ τὸ τὴν θάλατταν μὴ διδόναι διαπνοὴν τῷ ὑπὸ τὴν γῆν ὡρμημένῳ πνεύματι, ἀλλ' ἀντιφράττειν· ἀποβιαζόμενα γὰρ ἄλληλα τὸ μὲν πνεῦμα τὸν σεισμὸν ἐποίησεν, ἡ δ' ὑπόστασις τοῦ κύματος τὸν κατακλυσμόν.

[1] ἐκεῖ—ἔξω O.T.: ἔξω—ἐκεῖ Fobes.

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[a] *Cf.* l. 34 below. [b] *Cf.* 343 b 2 and note.

earth seems to bellow as they say it does in fairy stories.

Water has sometimes burst out of the earth when there has been an earthquake. But this does not mean that the water was the cause of the shock. It is the wind which is the cause, whether it exerts its force on the surface [a] or from beneath—just as the winds are the cause of waves and not the waves of winds. Indeed one might as well suppose that the earth is the cause of the shock as that the water is: for in an earthquake it is overturned like water, and upsetting water is a form of overturning. But in fact both earth and water are material causes, being passive not active, but wind the motive cause. Water produced by earthquakes.

When a tidal wave coincides with an earthquake the cause is an opposition of winds. This happens when the wind which is causing the earthquake is unable quite to drive out the sea which is being driven in by another wind, but pushes it back and piles it together till a large mass has collected. Then if the first wind gives way the whole mass is driven in by the opposing wind and breaks on the land and causes a flood. This is what happened in Achaea.[b] For in Achaea there was a south wind, outside a north wind [c]; this was followed by a calm when the wind plunged into the earth, and so there was a tidal wave at the same time as the earthquake—an earthquake which was all the more violent because the sea gave no vent to the wind that had run into the earth, but blocked its passage. So in their mutual struggle the wind caused the earthquake, the wave by its subsidence the flood. Earthquakes and tidal waves.

[c] "Transpose ἔξω and ἐκεῖ ll. 6, 7. The map makes it clear that the received text is impossible" (O.T.).

368 b

Κατὰ μέρος δὲ γίγνονται οἱ σεισμοὶ τῆς γῆς, καὶ πολλάκις ἐπὶ μικρὸν τόπον, οἱ δ' ἄνεμοι οὔ· κατὰ μέρος μέν, ὅταν αἱ ἀναθυμιάσεις αἱ κατὰ τὸν τόπον αὐτὸν καὶ τὸν γειτνιῶντα συνέλθωσιν εἰς ἕν, ὥσπερ καὶ τοὺς αὐχμοὺς ἔφαμεν γίγνεσθαι καὶ τὰς ὑπερομβρίας τὰς κατὰ μέρος. καὶ οἱ μὲν σεισμοὶ γίγνονται διὰ[1] τοῦτον τὸν τρόπον, οἱ δ' ἄνεμοι οὔ· τὰ μὲν γὰρ ἐν τῇ γῇ τὴν ἀρχὴν ἔχει, ὥστ' ἐφ' ἓν ἁπάσας ὁρμᾶν· ὁ δ' ἥλιος[2] οὐχ ὁμοίως δύναται, τὰς δὲ μετεώρους μᾶλλον, ὥστε ῥεῖν, ὅταν ἀρχὴν λάβωσιν ἀπὸ τῆς τοῦ ἡλίου φορᾶς ἤδη κατὰ τὰς διαφορὰς τῶν τόπων, ἐφ' ἕν.

Ὅταν μὲν οὖν ᾖ πολὺ τὸ πνεῦμα, κινεῖ τὴν γῆν, ὥσπερ δὲ ὁ τρόμος, ἐπὶ πλάτος· γίγνεται δ' ὀλιγάκις καὶ κατά τινας τόπους, οἷον σφυγμός, ἄνω κάτωθεν· διὸ καὶ ἐλαττονάκις σείει τοῦτον τὸν τρόπον· οὐ γὰρ [δίδωσιν][3] ῥᾴδιον οὕτω πολλὴν συνελθεῖν ἀρχήν· ἐπὶ μῆκος γὰρ πολλαπλασία τῆς ἀπὸ τοῦ βάθους ἡ διάκρισις. ὅπου δ' ἂν γένηται τοιοῦτος σεισμός, ἐπιπολάζει πλῆθος λίθων, ὥσπερ τῶν ἐν τοῖς λίκνοις ἀναβραττομένων· τοῦτον γὰρ τὸν τρόπον γενομένου σεισμοῦ τά τε περὶ Σίπυλον ἀνετράπη καὶ τὸ Φλεγραῖον καλούμενον πεδίον καὶ τὰ περὶ τὴν Λιγυστικὴν χώραν.

Ἐν δὲ ταῖς νήσοις ταῖς ποντίαις ἧττον γίγνονται σεισμοὶ τῶν προσγείων· τὸ γὰρ πλῆθος τῆς θαλάττης καταψύχει τὰς ἀναθυμιάσεις καὶ κωλύει τῷ

[1] *κατὰ* W.
[2] *ὁρμᾶν ὁ ἥλιος* O.T.
[3] seclusit Fobes.

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[a] *Cf.* 360 b 17.
[b] The O.T., following Thurot, regards the text of ll. 17-22

Earthquakes are confined to one locality, often quite a small one, but winds are not. They are localized when the exhalations of a particular locality and its neighbour combine, which was what we said [a] happens in local droughts and rainy seasons. Earthquakes are produced in this way, but not winds. For rains, droughts and earthquakes originate in the earth, and so their constituent exhalations tend to move all in one direction; the sun has less power over them than it has with the exhalations in the air which therefore flow on in one direction when the sun's movement gives them an impulse, differing according to the difference of its position.[b] Why earthquakes are local

So then, when the quantity of wind is large it causes an earthquake shock which runs horizontally, like a shudder. occasionally in some places the shock runs up from below, like a throb. The latter type of shock is therefore the rarer, for sufficient force to cause it does not easily collect since there is many times as much of the exhalation that causes shocks horizontally as of that which causes them from below. But whenever this type of earthquake does occur, large quantities of stones come to the surface, like the chaff in a winnowing sieve. This kind of earthquake it was that devastated the country round Sipylos, the so-called Phlegraean plain and the districts of Liguria. Horizontal and vertical shocks

Earthquakes are rarer in islands that are far out at sea than in those close to the mainland. For the quantity of the sea cools the exhalations and its Earthquakes and islands.

as corrupt. In my attempt to make sense of it I follow Alex.'s explanation (124. 28 ff.), taking τὰ μέν l. 18 to mean rains, etc., and understanding τὰς ἀναθυμιάσεις with ἁπάσας l. 19. The general point of the paragraph, as the O.T. remarks, is to contrast the local nature of earthquakes with the wide range of winds.

368 b βάρει καὶ ἀποβιάζεται· ἔτι δὲ ῥεῖ καὶ οὐ σείεται
369 a κρατουμένη ὑπὸ τῶν πνευμάτων· καὶ διὰ τὸ πολὺν ἐπέχειν τόπον οὐκ εἰς ταύτην ἀλλ' ἐκ ταύτης αἱ ἀναθυμιάσεις γίγνονται, καὶ ταύταις ἀκολουθοῦσιν αἱ ἐκ τῆς γῆς. αἱ δ' ἐγγὺς τῆς ἠπείρου μόριόν
5 εἰσιν τῆς ἠπείρου· τὸ γὰρ μεταξὺ διὰ μικρότητα οὐδεμίαν ἔχει δύναμιν· τὰς δὲ ποντίας οὐκ ἔστιν κινῆσαι ἄνευ τῆς θαλάττης ὅλης, ὑφ' ἧς περιεχόμεναι τυγχάνουσιν.

Περὶ μὲν οὖν σεισμῶν, καὶ τίς ἡ φύσις, καὶ διὰ τίνα αἰτίαν γίγνονται, καὶ περὶ τῶν ἄλλων τῶν συμβαινόντων περὶ αὐτούς, εἴρηται σχεδὸν περὶ τῶν μεγίστων.

CHAPTER IX

ARGUMENT

Thunder is due to the forcible ejection of the dry exhalation trapped in the clouds in the process of condensation (369 a 10–b 3). *The ejected exhalation usually catches fire, and this produces lightning (which thus occurs, in spite of appearances,*

369 a 10 Περὶ δὲ ἀστραπῆς καὶ βροντῆς, ἔτι δὲ περὶ τυφῶνος καὶ πρηστῆρος καὶ κεραυνῶν λέγωμεν· καὶ γὰρ τούτων τὴν αὐτὴν ἀρχὴν ὑπολαβεῖν δεῖ πάντων.

Τῆς γὰρ ἀναθυμιάσεως, ὥσπερ εἴπομεν, οὔσης διττῆς, τῆς μὲν ὑγρᾶς τῆς δὲ ξηρᾶς, καὶ τῆς συγ-
15 κρίσεως ἐχούσης ἄμφω ταῦτα δυνάμει καὶ συνισταμένης εἰς νέφος, ὥσπερ εἴρηται πρότερον, ἔτι δὲ πυκνοτέρας τῆς συστάσεως τῶν νεφῶν γιγνο-

weight crushes them and prevents their forming; and the force of the winds causes waves and not shocks in the sea. Again, its extent is so great that the exhalations do not run into it but are produced from it and joined by those from the land. On the other hand, islands close to the mainland are for all practical purposes part of it, the interval between them being too small to be effective. And islands out at sea can feel no shock that is not felt by the whole of the sea by which they are surrounded.

This completes our explanation of the nature and cause of earthquakes, and of their most important attendant circumstances.

CHAPTER IX

ARGUMENT (*continued*)

after thunder) (369 b 3-11). *Theories of Empedocles and Anaxagoras stated and criticized* (369 b 11—370 a 10). *Theory of Cleidemus and others* (370 a 10-21). *Summary and conclusion* (370 a 21-34).

Thunder caused by the forcible ejection of dry exhalation from cloud.

LET us now explain lightning and thunder, and then whirlwinds, firewinds and thunderbolts: for the cause of all of them must be assumed to be the same.

As we have said,[a] there are two kinds of exhalation, moist and dry; and their combination (air) contains both potentially. It condenses into cloud, as we have explained before,[b] and the condensation of clouds

[a] *Cf.* 341 b 6 ff.
[b] *Cf.* 346 b 23 ff., 359 b 34 ff.

μένης πρὸς τὸ ἔσχατον πέρας (ᾗ γὰρ ἐκλείπει τὸ θερμὸν διακρινόμενον εἰς τὸν ἄνω τόπον, ταύτῃ πυκνοτέραν καὶ ψυχροτέραν ἀναγκαῖον εἶναι τὴν σύστασιν· διὸ καὶ οἱ κεραυνοὶ καὶ οἱ ἐκνεφίαι καὶ πάντα τὰ τοιαῦτα φέρεται κάτω, καίτοι πεφυκότος ἄνω τοῦ θερμοῦ φέρεσθαι παντός· ἀλλ' εἰς τοὐναντίον τῆς πυκνότητος ἀναγκαῖον γίγνεσθαι τὴν ἔκθλιψιν, οἷον οἱ πυρῆνες οἱ ἐκ τῶν δακτύλων ἐκπηδῶντες· καὶ γὰρ ταῦτα βάρος ἔχοντα φέρεται πολλάκις ἄνω)· ἡ μὲν οὖν ἐκκρινομένη θερμότης εἰς τὸν ἄνω διασπείρεται τόπον· ὅση δ' ἐμπεριλαμβάνεται τῆς ξηρᾶς ἀναθυμιάσεως ἐν τῇ μεταβολῇ ψυχομένου τοῦ ἀέρος, αὕτη συνιόντων τῶν νεφῶν ἐκκρίνεται, βίᾳ δὲ φερομένη καὶ προσπίπτουσα τοῖς περιεχομένοις νέφεσι ποιεῖ πληγήν, ἧς ὁ ψόφος καλεῖται βροντή. γίγνεται δ' ἡ πληγὴ τὸν αὐτὸν τρόπον, ὡς παρεικάσαι μείζονι μικρὸν πάθος, τῷ ἐν τῇ φλογὶ γιγνομένῳ ψόφῳ, ὃν καλοῦσιν οἱ μὲν τὸν Ἥφαιστον γελᾶν, οἱ δὲ τὴν Ἑστίαν, οἱ δ' ἀπειλὴν τούτων. γίγνεται δ' ὅταν ἡ ἀναθυμίασις εἰς τὴν φλόγα συνεστραμμένη φέρηται, ῥηγνυμένων καὶ ξηραινομένων τῶν ξύλων· οὕτως γὰρ καὶ ἐν τοῖς νέφεσι ἡ γιγνομένη τοῦ πνεύματος ἔκκρισις πρὸς τὴν πυκνότητα τῶν νεφῶν ἐμπίπτουσα ποιεῖ τὴν βροντήν. παντοδαποὶ δὲ ψόφοι διὰ τὴν ἀνωμαλίαν τε γίγνονται τῶν νεφῶν καὶ διὰ τὰς μεταξὺ κοιλίας, ᾗ τὸ συνεχὲς ἐκλείπει τῆς πυκνότητος.

Ἡ μὲν οὖν βροντὴ τοῦτ' ἔστι, καὶ γίγνεται διὰ ταύτην τὴν αἰτίαν· τὸ δὲ πνεῦμα τὸ ἐκθλιβόμενον τὰ πολλὰ μὲν ἐκπυροῦται λεπτῇ καὶ ἀσθενεῖ πυρώσει, καὶ τοῦτ' ἔστιν ἣν καλοῦμεν ἀστραπήν, ᾗ ἂν

is thicker towards their farther limit. (Condensation must be denser and colder where the heat gives out as it radiates into the upper region. This is the reason why thunderbolts and hurricanes and all such phenomena move downwards ; for although all heat naturally rises, they must be projected away from the dense formation. Analogously, when we make fruit stones jump from between our fingers, they often move upwards in spite of their weight.) Heat[a] when radiated disperses into the upper region. But any of the dry exhalation that gets trapped when the air is in process of cooling is forcibly ejected as the clouds condense and in its course strikes the surrounding clouds, and the noise caused by the impact is what we call thunder. The impact is produced in the same way (to compare small things with great) as the noise you get in a flame, which some people call Hephaestus's or Hestia's laugh, some their threat. This noise occurs when the exhalation is hurled bodily against the flame as the logs crack and dry ; similarly the windy exhalation in the clouds produces thunder when it strikes a dense cloud formation. Different kinds of sound are produced because of the lack of uniformity in the clouds and because hollows occur where their density is not continuous.

This, then, is what thunder is and this is its cause. As a rule, the ejected wind burns with a fine and gentle fire, and it is then what we call lightning, Lightning due to the same cause.

[a] *i.e.* the dry, warm exhalation.

369 b ὥσπερ ἐκπῖπτον τὸ πνεῦμα χρωματισθὲν ὀφθῇ. γίγνεται δὲ μετὰ τὴν πληγὴν καὶ ὕστερον τῆς βροντῆς· ἀλλὰ φαίνεται πρότερον διὰ τὸ τὴν ὄψιν προτερεῖν τῆς ἀκοῆς. δηλοῖ δ' ἐπὶ τῆς εἰρεσίας τῶν τριήρων· ἤδη γὰρ ἀναφερόντων πάλιν τὰς κώπας ὁ πρῶτος ἀφικνεῖται ψόφος τῆς κωπηλασίας.

Καίτοι τινὲς λέγουσιν ὡς ἐν τοῖς νέφεσιν ἐγγίγνεται πῦρ· τοῦτο δ' Ἐμπεδοκλῆς μέν φησιν εἶναι τὸ ἐμπεριλαμβανόμενον τῶν τοῦ ἡλίου ἀκτίνων, Ἀναξαγόρας δὲ τοῦ ἄνωθεν αἰθέρος, ὃ δὴ ἐκεῖνος καλεῖ πῦρ κατενεχθὲν ἄνωθεν κάτω. τὴν μὲν οὖν διάλαμψιν ἀστραπὴν εἶναι τὴν τούτου τοῦ πυρός, τὸν δὲ ψόφον ἐναποσβεννυμένου καὶ τὴν σίξιν βροντήν, ὡς καθάπερ φαίνεται καὶ γιγνόμενον οὕτως καὶ πρότερον τὴν ἀστραπὴν οὖσαν τῆς βροντῆς.

Ἄλογος δὲ καὶ ἡ τοῦ πυρὸς ἐμπερίληψις, ἀμφοτέρως μέν, μᾶλλον δ' ἡ κατάσπασις τοῦ ἄνωθεν αἰθέρος. τοῦ τε γὰρ κάτω φέρεσθαι τὸ πεφυκὸς ἄνω δεῖ λέγεσθαι τὴν αἰτίαν, καὶ διὰ τί ποτε τοῦτο γίγνεται κατὰ τὸν οὐρανὸν ὅταν ἐπινέφελον ᾖ μόνον, ἀλλ' οὐ συνεχῶς οὕτως· αἰθρίας δὲ οὔσης οὐ γίγνεται. τοῦτο γὰρ παντάπασιν ἔοικεν εἰρῆσθαι προχείρως. ὁμοίως δὲ καὶ τὸ τὴν ἀπὸ τῶν ἀκτίνων θερμότητα φάναι τὴν ἀπολαμβανομένην ἐν τοῖς νέφεσιν εἶναι τούτων αἰτίαν οὐ πιθανόν· καὶ γὰρ οὗτος ὁ λόγος ἀπραγμόνως εἴρηται λίαν· ἀποκεκριμένον τε γὰρ ἀναγκαῖον εἶναι τὸ αἴτιον ἀεὶ καὶ ὡρισμένον, τό τε τῆς βροντῆς καὶ τῆς ἀστραπῆς

which occurs when the falling wind appears to us as it were coloured. Lightning is produced after the impact and so later than thunder, but appears to us to precede it because we see the flash before we hear the noise. You can see this by watching the rowing of a trireme ; for the oars are already drawing back again when the sound of the stroke which they have made first reaches us.

Views of Empedocles and Anaxagoras stated,

Some, however, say that there is fire in the clouds. This Empedocles [a] supposes to be some of the sun's rays trapped in the clouds, Anaxagoras [b] to be a part of the upper aether which he calls fire and which has descended into the lower atmosphere. Lightning they then suppose to be this fire flashing through the clouds, thunder the noise of it hissing when quenched ; so the apparent order of the two is the real order and lightning precedes thunder.

and criticized.

The enclosure of the fire is difficult to account for on both views. The difficulty is greater on the view that it is drawn down from the upper aether. For we should be told the reason for the downward movement of something whose natural movement is upwards, and further why this happens only when the sky is cloudy and not all the time, since it does not happen in clear weather. The theory seems altogether too hasty. It is, however, equally unconvincing to say that the cause is the heat of the sun's rays cut off in the clouds, and this theory too must be pronounced to be ill-considered. For there must be a separate and distinct cause of the occurrence of each phenomenon, whether thunder or lightning or any-

[a] Diels 31 A 62.

[b] Diels 59 A 1 (9), 42 (11), 84 : *cf.* 339 b 21 (Book I. ch. 3) for Anaxagoras on the aether.

369 b
καὶ τῶν ἄλλων τῶν τοιούτων, καὶ οὕτω γίγνεσθαι. τοῦτο δὲ διαφέρει πλεῖστον· ὅμοιον γὰρ κἂν εἴ τις οἴοιτο τὸ ὕδωρ καὶ τὴν χιόνα καὶ τὴν χάλαζαν ἐννυπάρχοντα πρότερον ὕστερον ἐκκρίνεσθαι καὶ μὴ γίγνεσθαι, οἷον ὑπὸ χεῖρα ποιούσης ἀεὶ τῆς συγκρίσεως ἕκαστον αὐτῶν· ὡσαύτως γὰρ ἐκεῖνά τε συγκρίσεις καὶ ταῦτα διακρίσεις ὑπολεπτέον εἶναι, ὥστ' εἰ θάτερα τούτων μὴ γίγνεται ἀλλ' ἔστι,
370 a περὶ ἀμφοτέρων ὁ αὐτὸς ἁρμόσει λόγος. τήν τ' ἐναπόληψιν τί ἂν ἀλλοιότερον λέγοι τις ἢ καθάπερ ἐν τοῖς πυκνοτέροις; καὶ γὰρ τὸ ὕδωρ ὑπὸ τοῦ ἡλίου καὶ τοῦ πυρὸς γίγνεται θερμόν· ἀλλ' ὅμως ὅταν πάλιν συνίῃ καὶ ψύχηται τὸ ὕδωρ πηγνύμενον,
5 οὐδεμίαν συμβαίνει γίγνεσθαι τοιαύτην ἔκπτωσιν οἵαν ἐκεῖνοι λέγουσιν· καίτοι[1] γ' ἐχρῆν κατὰ λόγον τοῦ μεγέθους. τὴν[2] δὲ ζέσιν ποιεῖν τὸ ἐγγιγνόμενον πνεῦμα ὑπὸ τοῦ πυρός, ἣν οὔτε δυνατὸν ἐννυπάρχειν πρότερον, οὔτ' ἐκεῖνοι τὸν ψόφον ζέσιν ποιοῦσιν ἀλλὰ σίξιν· ἔστι δὲ καὶ ἡ σίξις μικρὰ
10 ζέσις· ἢ γὰρ τὸ προσπῖπτον κρατεῖ σβεννύμενον, ταύτῃ ζέον ποιεῖ τὸν ψόφον.

Εἰσὶ δέ τινες οἳ τὴν ἀστραπήν, ὥσπερ καὶ Κλείδημος, οὐκ εἶναί φασιν ἀλλὰ φαίνεσθαι, παρεικάζοντες ὡς τὸ πάθος ὅμοιον ὂν καὶ ὅταν τὴν θάλαττάν τις ῥάβδῳ τύπτῃ· φαίνεται γὰρ τὸ ὕδωρ ἀποστίλβον τῆς νυκτός· οὕτως ἐν τῇ νεφέλῃ ῥαπι-

[1] *λέγουσι. καίτοι* Fobes.
[2] *μεγέθους. τὴν* interpunxit O.T.: δὲ E $\mathfrak{W}_1$ F_1 O.T., om. Fobes.

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[a] I have followed the O.T. readings in ll. 5, 6, though Fobes's text is that which Alex. had. On the readings I have adopted Aristotle seems to be making two points in 370 a 1-10:

thing else. But the cause proposed is far from fulfilling this requirement. It is rather as if one supposed that water and snow and hail emerged ready-made, and did not have to be formed because the atmosphere has a stock ready to hand for each occasion For we must suppose that the same is true of products of condensation, like water, snow and hail, and of products of ejection like thunder and lightning; so that if it is true of either that they are not formed but exist ready made, the same argument will apply to both Again, how are we to say that interception by cloud differs from interception by denser bodies? For water too is warmed by the sun and by fire. Yet when it contracts again and is cooled still further and freezes there is no ejection such as they describe, though on their theory there should be to a duly proportionate extent. And boiling is caused by the wind produced in water by fire and cannot exist in the water beforehand; and though they do not call the noise boiling but hissing, yet hissing is boiling in miniature (for when the fire on impact is quenched yet masters the moisture, it boils and causes the noise).[a]

View of Cleidemus and others stated and criticized.

There are some, for instance Cleidemus,[b] who say that lightning has no objective existence but is an appearance only. They compare it to the visual experience one has when the sea is struck with a stick at night and the water seems to flash, and say

(1) Fire ought also to be intercepted by water when heated and a noise analogous to lightning therefore be produced when it is cooled. (2) We know that boiling is not produced by fire already in water; yet hissing, to which thunder is compared, is merely boiling in miniature (and so hissing cannot be produced by fire already in water either).

[b] Diels 62. 1.

370 a
15 ζομένου τοῦ ὑγροῦ τὴν φάντασιν τῆς λαμπρότητος εἶναι τὴν ἀστραπήν. οὗτοι μὲν οὖν οὔπω συνήθεις ἦσαν ταῖς περὶ τῆς ἀνακλάσεως δόξαις, ὅπερ αἴτιον δοκεῖ τοῦ τοιούτου πάθους εἶναι· φαίνεται γὰρ τὸ ὕδωρ στίλβειν τυπτόμενον ἀνακλωμένης ἀπ' αὐτοῦ τῆς ὄψεως πρός τι τῶν λαμπρῶν. διὸ καὶ γί-
20 γνεται μᾶλλον τοῦτο νύκτωρ· τῆς γὰρ ἡμέρας οὐ φαίνεται διὰ τὸ πλέον ὂν τὸ φέγγος τὸ τῆς ἡμέρας ἀφανίζειν.

Τὰ μὲν οὖν λεγόμενα περὶ βροντῆς τε καὶ ἀστραπῆς παρὰ τῶν ἄλλων ταῦτ' ἐστί, τῶν μὲν ὅτι ἀνάκλασις ἡ ἀστραπή, τῶν δ' ὅτι πυρὸς μὲν ἡ ἀστραπὴ διάλαμψις, ἡ δὲ βροντὴ σβέσις, οὐκ ἐγγι-
25 γνομένου παρ' ἕκαστον πάθος τοῦ πυρὸς ἀλλ' ἐνυπάρχοντος. ἡμεῖς δέ φαμεν τὴν αὐτὴν εἶναι φύσιν ἐπὶ μὲν τῆς γῆς ἄνεμον, ἐν δὲ τῇ γῇ σεισμόν, ἐν δὲ τοῖς νέφεσι βροντήν· πάντα γὰρ εἶναι ταῦτα τὴν οὐσίαν ταὐτόν, ἀναθυμίασιν ξηράν, ἣ ῥέουσα μέν πως ἄνεμός ἐστιν, ὠδὶ δὲ ποιεῖ τοὺς σεισμούς, ἐν
30 δὲ τοῖς νέφεσι μεταβάλλουσι[1] ἐκκρινομένη,[2] συνιόντων καὶ συγκρινομένων αὐτῶν εἰς ὕδωρ, βροντάς τε καὶ ἀστραπὰς καὶ πρὸς τούτοις τἆλλα τὰ τῆς αὐτῆς φύσεως τούτοις ὄντα. καὶ περὶ μὲν βροντῆς εἴρηται καὶ ἀστραπῆς.

[1] *μεταβάλλουσι* cl. Thurot: *μεταβάλλουσα* Fobes codd.: om. J F M.
[2] *ἐκκρινομένη* E M (Ap): *διακρινομένη* Fobes.

that lightning is a similar appearance of brightness produced when the moisture in the cloud is struck. These people had no acquaintance with theories of reflection, which is now generally recognized as the cause of this kind of phenomenon The water seems to flash when struck because our line of vision is reflected from it to some bright object. This happens more often at night, for the greater brightness of the daylight prevents it being observed

Conclusion

These are the views held by others about thunder and lightning : some think lightning is a reflection, others that lightning is fire flashing through the clouds, thunder the noise of its quenching, and that the fire does not come into being on each occasion but exists already. Our own view is that the same natural substance causes wind on the earth's surface, earthquakes beneath it, and thunder in the clouds ; for all these have the same substance, the dry exhalation. If it flows in one way it is wind, in another it causes earthquakes ; and when the clouds change in the process of contracting and condensing into water, it is ejected and causes thunder and lightning, and all other phenomena of the same nature. So much for thunder and lightning.

BOOK III

CHAPTER I

ARGUMENT (*continued*)

typhoon (370 b 17—371 a 15). *A firewind is a whirlwind that has caught fire* (371 a 15-17). *Thunderbolts, of two kinds, are similarly due to wind ; as can be seen from their effects and from analogies* (371 a 17–b 14). *Conclusion* (371 b 14-17).

Thunder, lightning and hurricanes the products of exhalation

LET us deal now with the remaining effects of this process of exhalation, proceeding on the method we have before adopted.

The windy exhalation causes thunder and lightning when it is produced in small quantities, widely dispersed, and at frequent intervals, and when it spreads quickly and is of extreme rarity. But when it is produced in a compact mass and is denser, the result is a hurricane, which owes its violence to the force which the speed of its separation gives it.

When there is an abundant and constant flow of exhalation the process is similar to the opposite process which produces rain and large quantities of water. Both possibilities are latent in the material,[a]

[a] Alex (134 15) thinks the "material" is cloud, which contains exhalations of both kinds, *cf.* 358 a 21 : but so also does air, *cf.* 340 b 14-32, 341 b 6.

370 b δυνάμει ταῦτα κατὰ τὴν ὕλην· ὅταν δὲ ἀρχὴ γένηται
τῆς δυνάμεως ὁποτερασοῦν, ἀκολουθεῖ συγκρινό-
μενον ἐκ τῆς ὕλης ὁποτέρου ἂν ᾖ πλῆθος ἐνυπάρχον
πλέον, καὶ γίγνεται τὸ μὲν ὄμβρος, τὸ δὲ τῆς
ἑτέρας ἀναθυμιάσεως ἐκνεφίας.

Ὅταν δὲ τὸ ἐκκρινόμενον πνεῦμα τὸ ἐν τῷ νέφει
ἑτέρῳ ἀντιτυπήσῃ οὕτως ὥσπερ ὅταν ἐξ εὐρέος εἰς
στενὸν βιάζηται ὁ ἄνεμος ἐν πύλαις ἢ ὁδοῖς (συμ-
βαίνει γὰρ πολλάκις ἐν τοῖς τοιούτοις ἀπωσθέντος
τοῦ πρώτου μορίου τοῦ ῥέοντος σώματος διὰ τὸ
μὴ ὑπείκειν, ἢ διὰ στενότητα ἢ διὰ τὸ ἀντιπνεῖν,
κύκλον καὶ δίνην γίγνεσθαι τοῦ πνεύματος· τὸ μὲν
γὰρ εἰς τὸ πρόσθεν κωλύει προιέναι, τὸ δ' ὄπισθεν
ἐπωθεῖ, ὥστε ἀναγκάζεται εἰς τὸ πλάγιον, ᾗ οὐ
κωλύεται, φέρεσθαι, καὶ οὕτως ἀεὶ τὸ ἐχόμενον,
ἕως ἂν ἓν γένηται, τοῦτο δ' ἐστὶ κύκλος· οὗ γὰρ
μία φορὰ σχήματος, τοῦτο καὶ αὐτὸ ἀνάγκη ἓν
εἶναι)· ἐπί τε τῆς γῆς οὖν διὰ ταῦτα γίγνονται οἱ
δῖνοι, καὶ ἐν τοῖς νέφεσιν ὁμοίως κατὰ τὴν ἀρχήν,
πλὴν ὅτι, ὥσπερ, ὅταν ἐκνεφίας γίγνηται, ἀεὶ τοῦ
νέφους[1] ἐκκρίνεται καὶ γίγνεται συνεχὴς ἄνεμος,
οὕτως ἐνταῦθα ἀεὶ τὸ ⟨νέφος⟩[2] συνεχὲς ἀκολουθεῖ
[τοῦ νέφους][3]· διὰ δὲ πυκνότητα οὐ δυνάμενον ἐκ-
κριθῆναι τὸ πνεῦμα ἐκ τοῦ νέφους στρέφεται μὲν
κύκλῳ τὸ πρῶτον διὰ τὴν εἰρημένην αἰτίαν, κάτω
371 a δὲ φέρεται διὰ τὸ ἀεὶ τὰ νέφη πυκνοῦσθαι, ᾗ
ἐκπίπτει τὸ θερμόν. καλεῖται δ', ἂν ἀχρωμάτιστον

[1] *τοῦ νέφους* Β var. $H_{ori\ m\ 1}$ M Ap (ut videtur) O.T. : *τὸ νέφος* Fobes cett.
[2] *νέφος* ci. Thurot.
[3] *τοῦ νέφους* del. Thurot.

[a] The text of ll. 28-31 (*πλὴν ὅτι . . . νέφους*) and the mean-

and when an impulse is given which may lead to the development of either, the one of which there is the greater quantity latent in the material is forthwith formed from it, and either rain, or, if it is the other exhalation that predominates, a hurricane is produced.

When the wind produced in the cloud runs against another the result is similar to that produced when the wind is forced from a wide into a narrow place in a gateway or road. In such circumstances the first part of the stream is thrust aside by the resistance either of the narrow entrance or of the contrary wind and as a result forms a circular eddy of wind For its forward part prevents it from going forward, while its hinder part pushes it from behind, and so it is forced to flow sideways where there is no resistance. This happens to each succeeding part of the stream, till finally it forms a single body whose shape is circular; for any figure that is formed by a single motion must itself be single. This, then, is the cause of wind eddies on the earth, and they start in a similar way in the clouds. There, however, just as when a hurricane is produced, the wind is in continuous process of separation from the cloud, so in a whirlwind the cloud follows the windstream continuously[a]; and because of the cloud's density the wind is unable to separate itself from it and so is forced round in a circle at first (for the reason given above), and then descends because the clouds always condense where the heat leaves them.[b] The Whirlwinds

ing of the passage are uncertain. With the text as printed the point appears to be a comparison of hurricane and whirlwind; in both these is a constant production of wind from cloud, but in the whirlwind the cloud *follows* the wind. This comparison is incidental to the main comparison in 370 b 17—371 a 2 of the wind eddy on land and the wind eddy in the air.

[b] *Cf.* 369 a 16.

371 a

ἦ, τοῦτο τὸ πάθος τυφῶν ἄνεμος, ὢν οἷον[1] ἐκνεφίας ἄπεπτος. βορείοις δ' οὐ γίγνεται τυφῶν, οὐδὲ νιφετῶν[2] ὄντων ἐκνεφίας, διὰ τὸ πάντα ταῦτ' εἶναι πνεῦμα, τὸ δὲ πνεῦμα ξηρὰν εἶναι καὶ θερμὴν ἀναθυμίασιν. ὁ οὖν πάγος καὶ τὸ ψῦχος διὰ τὸ κρατεῖν σβέννυσιν εὐθὺς γιγνομένην ἔτι τὴν ἀρχήν. ὅτι δὲ κρατεῖ, δῆλον· οὐδὲ γὰρ ἂν ἦν νιφετός, οὐδὲ βόρεια τὰ ὑγρά· ταῦτα γὰρ συμβαίνει κρατούσης εἶναι τῆς ψυχρότητος. γίγνεται μὲν οὖν τυφῶν, ὅταν ἐκνεφίας γιγνόμενος μὴ δύνηται ἐκκριθῆναι τοῦ νέφους· ἔστι δὲ διὰ τὴν ἀντίκρουσιν τῆς δίνης, ὅταν ἐπὶ γῆν φέρηται ἡ ἕλιξ συγκατάγουσα τὸ νέφος, οὐ δυναμένη ἀπολυθῆναι. ᾗ δὲ κατ' εὐθυωρίαν ἐκπνεῖ, ταύτῃ τῷ πνεύματι κινεῖ, καὶ τῇ κύκλῳ κινήσει στρέφει καὶ ἀναφέρει ᾧ ἂν προσπέσῃ βιαζόμενον.

Ὅταν δὲ κατασπώμενον ἐκπυρωθῇ (τοῦτο δ' ἐστὶν ἐὰν λεπτότερον τὸ πνεῦμα γένηται), καλεῖται πρηστήρ· συνεκπίμπρησι γὰρ τὸν ἀέρα τῇ πυρώσει χρωματίζων.

Ἐὰν δ' ἐν αὐτῷ τῷ νέφει πολὺ καὶ λεπτὸν ἐκθλιφθῇ πνεῦμα, τοῦτο γίγνεται κεραυνός, ἐὰν μὲν πάνυ λεπτόν, οὐκ ἐπικάων διὰ λεπτότητα, ὃν οἱ ποιηταὶ ἀργῆτα καλοῦσιν, ἐὰν δ' ἧττον, ἐπικάων, ὃν ψολόεντα καλοῦσιν· ὁ μὲν γὰρ διὰ τὴν λεπτότητα φέρεται, διὰ δὲ τὸ τάχος φθάνει διιὼν πρὶν ἢ ἐκπυρῶσαι καὶ ἐπιδιατρίψας μελᾶναι· ὁ δὲ βραδύτερος ἔχρωσε μέν, ἔκαυσε δ' οὔ, ἀλλ' ἔφθασε. διὸ καὶ

[1] *τυφῶν, ἄνεμος ὤν, οἷον* Fobes.

[2] *νιφετῶν ὄντων* E_{corr} M B F H N Ol: *νιπτικῶν ἐχόντων* $\mathfrak{W}$: aut *νιπτικῶς ἐχόντων* aut *νιπτικῶν ἐχόντων* E_1; *νιπτικῶς ἐχόντων* Fobes.

resulting phenomenon, when colourless, is called a whirlwind, being a kind of unripe hurricane. Whirlwinds do not occur when the wind is in the north, nor hurricanes when there is snow. For all these phenomena are wind, and wind is dry and warm exhalation; frost and cold therefore master and smother this at the outset. It is clear that they do master it, otherwise there would be no snow nor would rains come from the north, which can only happen when the cold has the mastery. A whirlwind thus arises when a hurricane that has been produced is unable to free itself from the cloud: it is caused by the resistance of the eddy, and occurs when the spiral sinks to the earth and carries with it the cloud from which it is unable to free itself. Its blast overturns anything that lies in its path, and its circular motion whirls away and carries off by force anything it meets.

Firewinds

When the wind that is drawn down catches fire—which happens when it is finer in texture—it is called a firewind; for its conflagration sets on fire and so colours the neighbouring air.

Thunderbolts.

If a large quantity of wind of fine texture is squeezed out in the cloud itself, the result is a thunderbolt; if the wind is very fine in texture and in consequence does not scorch, the bolt is of the kind called by the poets gleaming; if the wind is less fine textured and so scorches, the bolt is of the kind they call smoky. For the one kind moves rapidly [a] because of its fineness, and because of its rapidity passes through the object before it can burn it or remain long enough to blacken it; while the other kind, moving more slowly, blackens the object but still moves too fast to burn

[a] The sense demands a complement to *φέρεται*: Thurot suggests *διὰ τάχους*.

371 a
25 τὰ μὲν ἀντιτυπήσαντα πάσχει τι, τὰ δὲ μὴ οὐδέν, οἷον ἀσπίδος ἤδη τὸ μὲν χάλκωμα ἐτάκη, τὸ δὲ ξύλον οὐδὲν ἔπαθεν· διὰ γὰρ μανότητα ἔφθασε τὸ πνεῦμα διηθηθέν· καὶ διελθὸν[1] καὶ δι' ἱματίων ὁμοίως οὐ κατέκαυσεν, ἀλλ' οἷον τρῦχος ἐποίησεν.
30 Ὥστε ὅτι γε πνεῦμα ταῦτα πάντα, δῆλον καὶ ἐκ τῶν τοιούτων. ἔστι δ' ἐνίοτε καὶ τοῖς ὄμμασιν θεωρεῖν, οἷον καὶ νῦν ἐθεωροῦμεν περὶ τὸν ἐν Ἐφέσῳ ναὸν καόμενον· πολλαχῇ γὰρ ἡ φλὸξ ἐφέρετο συνεχής, ἀποσπωμένη χωρίς. ὅτι μὲν γὰρ
371 b ὅ τε καπνὸς πνεῦμα καὶ κάεται ὁ καπνός, φανερόν, καὶ εἴρηται ἐν ἑτέροις πρότερον· ὅταν δ' ἀθρόον χωρῇ, τότε φανερῶς δοκεῖ πνεῦμα εἶναι. ὅπερ οὖν ἐν ταῖς μικραῖς πυρκαϊαῖς φαίνεται, τοῦτο καὶ τότε πολλῆς ὕλης καομένης ἐγίγνετο πολλῷ ἰσχυ-
5 ρότερον. ῥηγνυμένων οὖν τῶν ξύλων, ὅθεν ἡ ἀρχὴ τοῦ πνεύματος ἦν, πολὺ ἐχώρει ἀθρόον, ᾗ ἐξέπνει, καὶ ἐφέρετο ἄνω πεπυρωμένον. ὥστ' ἐφαίνετο ἡ φλὸξ φέρεσθαι καὶ εἰσπίπτειν εἰς τὰς οἰκίας. ἀεὶ γὰρ οἴεσθαι δεῖ ἐπακολουθεῖν τοῖς κεραυνοῖς πνεῦμα καὶ προϊέναι· ἀλλ' οὐχ ὁρᾶται, διὰ τὸ ἀχρωμά-
10 τιστον εἶναι. διὸ καὶ ᾗ μέλλει πατάξειν, κινεῖται πρὶν πληγῆναι, ἅτε πρότερον προσπιπτούσης τῆς ἀρχῆς τοῦ πνεύματος. καὶ αἱ βρονταὶ δὲ διιστᾶσιν οὐ τῷ ψόφῳ, ἀλλ' ὅτι ἅμα συνεκκρίνεται τὸ τὴν πληγὴν ποιῆσαν καὶ τὸν ψόφον πνεῦμα· ὃ ἐὰν πατάξῃ, διέστησεν, ἐπέκαυσε δ' οὔ.

[1] διηθηθὲν καὶ διελθόν· Fobes: διηθηθέν καὶ διελθὸν Thurot O.T.

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[a] So Alex. 138. 8.
[b] 356 B.C.
[c] 341 b 21, *cf.* 388 a 2; *De Gen. et Corr.* 331 b 25.

it. So objects which offer resistance suffer, those which offer none do not—for instance, the bronze head of a spear has been known to melt while the wooden handle was unaffected, the reason being that the wind percolated through the wood without affecting it because of the rareness of its texture. Similarly it has passed through garments without burning them, but leaving them threadbare.[a]

Such instances are in themselves conclusive evidence that all these phenomena are due to wind. But sometimes we get ocular evidence too, the burning of the temple of Ephesus[b] being a recent example; for it was observed then that sheets of flame were torn off from the main conflagration and carried in all directions It is evident, and we have already demonstrated elsewhere,[c] that smoke is wind and that smoke burns; and when the flame moves in a body, then it can be seen clearly that it is wind. Thus what is obvious in small conflagrations took place on that occasion with considerably more violence owing to the quantity of material that was being burned For when the beams in which the wind originated cracked, it issued in a body at the place where it burst out and went up in flames. So the flame was seen moving through the air and falling on the neighbouring houses. We must, indeed, suppose that wind always follows and precedes thunderbolts, but remains invisible because colourless. So a place that is going to be struck moves before the blow falls, because the wind in which the bolt originates strikes the object first. Thunder also splits things, not by its noise, but because a single wind is produced which deals the blow and causes the noise; this if it strikes an object splits it but does not burn it.

371 b 15 Περὶ μὲν οὖν βροντῆς καὶ ἀστραπῆς καὶ ἐκνεφίου, ἔτι δὲ πρηστήρων τε καὶ τυφώνων καὶ κεραυνῶν, εἴρηται, καὶ ὅτι ταὐτὸ πάντα, καὶ τίς ἡ διαφορὰ πάντων αὐτῶν.

CHAPTER II

ARGUMENT

Haloes, rainbows, mock suns and rods are our next subject: and the characteristics of each must first be described (371 b 18-22). *Haloes* (371 b 22-26). *Rainbows* (371 b 26—372 a 10). *Mock suns and rods* (372 a 10-16). *All are*

371 b 18 Περὶ δὲ ἅλω καὶ ἴριδος, τί τε ἑκάτερον καὶ διὰ τίν' αἰτίαν γίγνεται, λέγωμεν, καὶ περὶ παρηλίων 20 καὶ ῥάβδων· καὶ γὰρ ταῦτα γίγνεται πάντα διὰ τὰς αὐτὰς αἰτίας ἀλλήλοις.

Πρῶτον δὲ δεῖ λαβεῖν τὰ πάθη καὶ τὰ συμβαίνοντα περὶ ἕκαστον αὐτῶν.

Τῆς μὲν οὖν ἅλω φαίνεται πολλάκις κύκλος ὅλος, καὶ γίγνεται περὶ ἥλιον καὶ σελήνην καὶ περὶ τὰ 25 λαμπρὰ τῶν ἄστρων, ἔτι δ' οὐδὲν ἧττον νυκτὸς ἢ ἡμέρας καὶ περὶ μεσημβρίαν ἢ δείλην· ἔωθεν δ' ἐλαττονάκις καὶ περὶ δύσιν.

Τῆς δ' ἴριδος οὐδέποτε γίγνεται κύκλος οὐδὲ μεῖζον ἡμικυκλίου τμῆμα· καὶ δύνοντος μὲν καὶ ἀνατέλλοντος ἐλαχίστου μὲν κύκλου, μεγίστη δ' ἡ ἁψίς, αἰρομένου δὲ μᾶλλον κύκλου μὲν μείζονος, 30 ἐλάττων δ' ἡ ἁψίς· καὶ μετὰ μὲν τὴν μετοπωρινὴν ἰσημερίαν, ἐν ταῖς βραχυτέραις ἡμέραις, πᾶσαν ὥραν γίγνεται τῆς ἡμέρας, ἐν δὲ ταῖς θεριναῖς οὐ γίγνεται περὶ μεσημβρίαν. οὐδὲ δὴ δυοῖν πλείους

This concludes our treatment of thunder, lightning and hurricanes, of firewinds, whirlwinds and thunderbolts; we have shown that they are all materially the same and described the differences between them. Conclusion.

CHAPTER II

ARGUMENT (*continued*)

caused by reflection (372 a 16-21). *Rainbows occur both by day and night* (372 a 21-29). *We must refer to the science of optics for the explanation of reflections. Reflecting surfaces sometimes reflect shape, sometimes colour only* (372 a 29–b 11).

We must now deal with haloes, rainbows, mock suns and rods, explaining what they are and what are their causes; for the same causes account for all of them.

First we must describe what the actual characteristics of each of these phenomena are.

The complete circle of a halo is often visible, round the sun and moon and round bright stars, and as frequently by night as by day, that is, at midday or in the afternoon; for they occur more rarely at dawn and sunset. Halo.

The rainbow never forms a complete circle, nor a segment of a circle larger than a semicircle. At sunrise and sunset the circle is smallest and the segment largest; when the sun is higher the circle is larger, the segment smaller.[a] After the autumn equinox, during the shorter days, it occurs at all hours of the day; but in summer it does not occur round about midday. Nor do more than two rainbows occur Rainbow.

[a] The size of the circle does not in fact vary.

371 b ἴριδες οὐ γίγνονται ἅμα. τούτων δὲ τρίχρως μὲν
372 a ἑκατέρα, καὶ τὰ χρώματα ταὐτὰ καὶ ἴσα τὸν
ἀριθμὸν ἔχουσιν ἀλλήλαις, ἀμυδρότερα δ' ἐν τῇ
ἐκτὸς καὶ ἐξ ἐναντίας κείμενα κατὰ τὴν θέσιν· ἡ
μὲν γὰρ ἐντὸς τὴν πρώτην ἔχει περιφέρειαν τὴν
μεγίστην φοινικίαν, ἡ δ' ἔξωθεν τὴν ἐλαχίστην μὲν
5 ἐγγύτατα δὲ πρὸς ταύτην, καὶ τὰς ἄλλας ἀνάλογον.
ἔστι δὲ τὰ χρώματα ταῦτα ἅπερ μόνα σχεδὸν οὐ
δύνανται ποιεῖν οἱ γραφεῖς· ἔνια γὰρ αὐτοὶ κεραν-
νύουσι, τὸ δὲ φοινικοῦν καὶ πράσινον καὶ ἁλουργὸν
οὐ γίγνεται κεραννύμενον· ἡ δὲ ἶρις ταῦτ' ἔχει τὰ
10 χρώματα. τὸ δὲ μεταξὺ τοῦ φοινικοῦ καὶ πρα-
σίνου φαίνεται πολλάκις ξανθόν.

Παρήλιοι δὲ καὶ ῥάβδοι γίγνονται ἐκ πλαγίας
αἰεὶ καὶ οὔτ' ἄνωθεν οὔτε πρὸς τῆς γῆς οὔτ' ἐξ
ἐναντίας, οὐδὲ δὴ νύκτωρ, ἀλλ' ἀεὶ περὶ τὸν ἥλιον,
ἔτι δὲ ἢ αἰρομένου ἢ καταφερομένου· τὰ πλεῖστα
δὲ πρὸς δυσμάς· μεσουρανοῦντος δὲ σπάνιον εἴ τι
15 γέγονεν, οἷον ἐν Βοσπόρῳ ποτὲ συνέπεσε· δι' ὅλης
γὰρ τῆς ἡμέρας συνανασχόντες δύο παρήλιοι διε-
τέλεσαν μέχρι δυσμῶν.

Τὰ μὲν οὖν περὶ ἕκαστον αὐτῶν συμβαίνοντα
ταῦτ' ἐστίν· τὸ δ' αἴτιον τούτων ἁπάντων ταὐτό·
πάντα γὰρ ἀνάκλασις ταῦτ' ἐστί. διαφέρουσι δὲ
τοῖς τρόποις καὶ ἀφ' ὧν, καὶ ὡς συμβαίνει γί-

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[a] The colours of the rainbow are six: red, orange, yellow, green, blue, violet. Aristotle reduces them to three by grouping red-orange-yellow, and blue-violet. But he notes that a yellow band (grouping orange-yellow) is often seen between the red and the green. The painters' primary colours are red, *yellow*, and blue; not red, *green*, and blue as Aristotle says. Green can be produced by mixing yellow and blue, but yellow cannot be produced by any mixture of red, green and blue.

at the same time. Of two such simultaneous rainbows each is three-coloured, the colours being the same in each and equal in number, but dimmer in the outer bow and placed in the reverse order. For in the inner bow it is the first and largest band that is red, in the outer it is the smallest and closest to the red band of the inner. And the other bands correspond similarly. These colours are almost the only ones that painters cannot manufacture ; for they produce some colours by a mixture of others, but red, green and blue cannot be produced in this way, and these are the colours of the rainbow—though between the red and green band there often appears a yellow one.[a]

Mock suns and rods always appear beside the sun, and not either above or below it or opposite it[b] ; nor of course do they appear at night, but always in the neighbourhood of the sun and either when it is rising or setting, and mostly towards sunset. They rarely if ever occur when the sun is high, though this did happen once in the Bosporus, where two mock suns rose with the sun and continued all day till sunset. Mock sun, rod

These, then, are the characteristics of these phenomena. The cause of all is the same, for they are all phenomena of reflection.[c] They differ in the manner of the reflection and in the reflecting surface, and All due to reflection

[b] *Cf.* 377 b 27 ff.

[c] Here as elsewhere in the *Meteorologica* (*e.g.* Book I. ch. 6, 343 a 2 and note) Aristotle speaks as if our sight were reflected *to* the object and not the object (or rays therefrom) reflected to our sight. Alex. (141) connects this with the view that in sight rays are projected from the eye to the object, for which *cf.* Plato, *Timaeus* 45 B ff., a view which Aristotle himself rejects (*De Anima* II. 7). But so far as the mathematics of the matter are concerned, which is all that is at issue here, it makes (as Alex. also remarks 141. 20) little difference which view is taken of reflection. *Cf.* Ideler ii. pp. 273-274.

372 a
γνεσθαι τὴν ἀνάκλασιν πρὸς τὸν ἥλιον ἢ πρὸς ἄλλο τι τῶν λαμπρῶν.

Καὶ μεθ' ἡμέραν μὲν ἶρις γίγνεται, νύκτωρ δ' ἀπὸ σελήνης, ὡς μὲν οἱ ἀρχαῖοι ᾠοντο, οὐκ ἐγίγνετο· τοῦτο δ' ἔπαθον διὰ τὸ σπάνιον· ἐλάνθανε γὰρ αὐτούς· γίγνεται μὲν γάρ, ὀλιγάκις δὲ γίγνεται. τὸ δ' αἴτιον ὅτι τ' ἐν τῷ σκότει λανθάνει τὰ χρώματα, καὶ ἄλλα πολλὰ δεῖ συμπεσεῖν, καὶ ταῦτα πάντα ἐν ἡμέρᾳ μιᾷ τοῦ μηνός· ἐν τῇ πανσελήνῳ γὰρ γενέσθαι ἀνάγκη τὸ μέλλον ἔσεσθαι, καὶ τότε ἀνατελλούσης ἢ δυνούσης· διόπερ ἐν ἔτεσιν ὑπὲρ τὰ πεντήκοντα δὶς ἐνετύχομεν μόνον.

Ὅτι μὲν οὖν ἡ ὄψις ἀνακλᾶται, ὥσπερ καὶ ἀφ' ὕδατος, οὕτω καὶ ἀπὸ ἀέρος καὶ πάντων τῶν ἐχόντων τὴν ἐπιφάνειαν λείαν, ἐκ τῶν περὶ τὴν ὄψιν δεικνυμένων δεῖ λαμβάνειν τὴν πίστιν, καὶ διότι τῶν ἐνόπτρων ἐν ἐνίοις μὲν καὶ τὰ σχήματα ἐμφαίνεται, ἐν ἐνίοις δὲ τὰ χρώματα μόνον· τοιαῦτα δ'
372 b ἐστὶν ὅσα μικρὰ τῶν ἐνόπτρων, καὶ μηδεμίαν αἰσθητὴν ἔχει διαίρεσιν· ἐν γὰρ τούτοις τὸ μὲν σχῆμα ἀδύνατον ἐμφαίνεσθαι (δόξει γὰρ εἶναι διαιρετόν· πᾶν γὰρ σχῆμα ἅμα δοκεῖ σχῆμά τ' εἶναι καὶ διαίρεσιν ἔχειν), ἐπεὶ δ' ἐμφαίνεσθαί τι ἀναγκαῖον, τοῦτο δὲ ἀδύνατον, λείπεται τὸ χρῶμα μόνον ἐμφαίνεσθαι. τὸ δὲ χρῶμα ὁτὲ μὲν λαμπρὸν φαίνεται τῶν λαμπρῶν, ὁτὲ δέ, ἢ τῷ μείγνυσθαι τῷ τοῦ ἐνόπτρου ἢ διὰ τὴν ἀσθένειαν τῆς ὄψεως, ἄλλου χρώματος ἐμποιεῖ φαντασίαν.

[a] "Since divisibility is involved in the notion of figure" (O.T.).

according as the reflection is to the sun or some other bright object.

The rainbow occurs by day, and also at night, when it is due to the moon, though early thinkers did not think this ever happened. Their opinion was due to the rarity of the phenomenon, which thus escaped their observation for though it does occur, it only does so rarely And the reason for this is that the darkness hides the colours, and a conjunction of many other circumstances is necessary, all of which must coincide upon a single day of the month, the day of the full moon For it is on that day that the phenomenon must occur if it is to occur at all, and occur then only at the moon's rising or setting So we have only met with two instances of it over a period of more than fifty years. Rainbows by day and night.

We must refer to what has been demonstrated by the science of optics as our ground for believing that our vision is reflected from the air and other substances which have a smooth surface, just as it is from water, and to the fact that in some mirrors shapes are reflected, in others colours only. Colours only are reflected in mirrors that are small and incapable of subdivision by our sense of sight. In these shape cannot be reflected. If it could be, it would be capable of subdivision, as all shape has the characteristics both of shape and of divisibility.[a] Since, then, something must necessarily be reflected, but shape cannot be, the only remaining possibility is that colour should be. The colour of bright objects sometimes appears bright in the reflection, but sometimes, either owing to contamination by the colour of the mirror or owing to the feebleness of our sight, produces an appearance of another colour. Optics provides the explanation

372 b

Ἔστω δὲ περὶ τούτων ἡμῖν τεθεωρημένον ἐν τοῖς περὶ τὰς αἰσθήσεις δεικνυμένοις· διὸ τὰ μὲν λέγωμεν, τοῖς δ' ὡς ὑπάρχουσι χρησώμεθα αὐτῶν.

CHAPTER III

ARGUMENT

The shape of the halo. Reflection takes place in certain conditions of cloud formation, and is a sign of various weather conditions (372 b 12-34). *The circularity of the halo*

372 b 12 Πρῶτον δὲ περὶ τῆς ἅλω τοῦ σχήματος εἴπωμεν, διότι τε κύκλος γίγνεται, καὶ διότι περὶ τὸν ἥλιον ἢ τὴν σελήνην, ὁμοίως δὲ καὶ περί τι τῶν ἄλλων ἄστρων· ὁ γὰρ αὐτὸς ἐπὶ πάντων ἁρμόσει λόγος

Γίγνεται μὲν οὖν ἡ ἀνάκλασις τῆς ὄψεως συνισταμένου τοῦ ἀέρος καὶ τῆς ἀτμίδος εἰς νέφος, ἐὰν ὁμαλὴς καὶ μικρομερὴς συνισταμένη τύχῃ. διὸ καὶ σημεῖον ἡ μὲν σύστασις ὕδατός ἐστιν, αἱ μέντοι διασπάσεις ἢ μαράνσεις, αὗται μὲν εὐδιῶν, αἱ δὲ διασπάσεις πνεύματος. ἐὰν μὲν γὰρ μήτε καταμαρανθῇ μήτε διασπασθῇ, ἀλλ' ἐαθῇ τὴν φύσιν ἀπολαμβάνειν τὴν αὑτῆς, ὕδατος εἰκότως σημεῖόν ἐστι· δηλοῖ γὰρ ἤδη γίγνεσθαι τοιαύτην τὴν σύστασιν, ἐξ ἧς τὸ συνεχὲς λαμβανούσης τῆς πυκνώσεως ἀναγκαῖον εἰς ὕδωρ ἐλθεῖν· διὸ καὶ μέλαιναι γί-

[a] The rest of this paragraph deals mainly with the halo as a weather-sign. But Aristotle's wording at the outset is confusing because *σύστασις* l. 18, after *συνισταμένη* in l. 17, at

But let us in these matters accept the results of our investigation of sensation, and mention some points only while taking the rest for granted.

CHAPTER III

ARGUMENT (*continued*)

geometrically explained (372 b 34—373 a 19). *Further characteristics of the reflecting cloud* (373 a 19-27) *Haloes more frequent round the moon than the sun They also form round the stars* (373 a 27-31).

The shape of the halo

LET us first deal with the shape of the halo and explain why it is round and why it appears round the sun or moon or similarly round one of the other stars. For the same explanation will fit all these cases.

Conditions of reflection: the halo as a weather sign

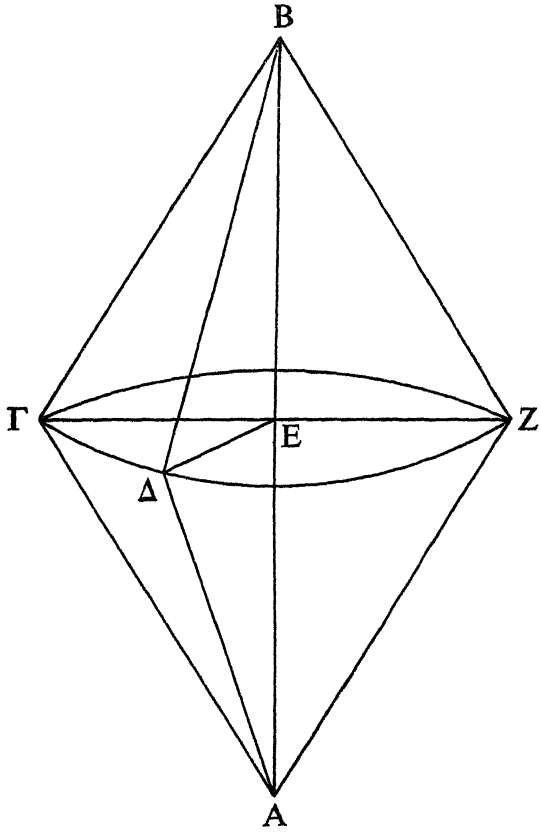
The reflection of our vision takes place when the air and vapour are condensed into cloud, if the condensation is uniform and its constituent particles small. This formation [a] is therefore a sign of rain, while if it is broken it is a sign of wind, if it fades, of fine weather. For if it neither fades nor breaks, but is allowed to reach its full development, it is reasonable to regard it as a sign of rain, since it shows that a condensation is taking place of the kind, which, if the condensing process continues, will necessarily lead to rain. And for this reason these haloes are

first sight seems to refer to the cloud formation and not to the halo. But it seems clear from what he says later (*e.g.* l. 25) that it is of the halo he is thinking: and the parallels quoted by Ideler (II. p. 277) confirm this. A full halo is a sign of rain, a broken halo of wind, a fading, dim halo of fine weather.

372 b γνονται τὴν χρόαν αὖται μάλιστα τῶν ἄλλων. ὅταν δὲ διασπασθῇ, πνεύματος σημεῖον· ἡ γὰρ διαίρεσις ὑπὸ πνεύματος γέγονεν ἤδη μὲν ὄντος, οὔπω δὲ παρόντος. σημεῖον δὲ τούτου διότι ἐντεῦθεν γίγνεται ὁ ἄνεμος, ὅθεν ἂν ἡ κυρία γίγνηται διάσπασις. ἀπομαραινομένη δὲ εὐδίας· εἰ γὰρ μὴ ἔχει πως οὕτως ὁ ἀὴρ ὥστε κρατεῖν τοῦ ἐναπολαμβανομένου θερμοῦ μηδ' ἔρχεσθαι εἰς πύκνωσιν ὑδατώδη, δῆλον ὡς οὔπω ἡ ἀτμὶς ἀποκέκριται τῆς ἀναθυμιάσεως [ἀπὸ][1] τῆς ξηρᾶς καὶ πυρώδους· τοῦτο δὲ εὐδίας αἴτιον.

Πῶς μὲν οὖν ἔχοντος τοῦ ἀέρος γίγνεται ἡ ἀνά-
373 a κλασις, εἴρηται. ἀνακλᾶται δ' ἀπὸ τῆς συνισταμένης ἀχλύος περὶ τὸν ἥλιον ἢ τὴν σελήνην ἡ ὄψις· διὸ οὐκ ἐξ ἐναντίας ὥσπερ ἶρις φαίνεται. πάντοθεν δὲ ὁμοίως ἀνακλωμένης ἀναγκαῖον κύκλον εἶναι ἢ κύκλου μέρος· ἀπὸ γὰρ τοῦ αὐτοῦ σημείου πρὸς τὸ αὐτὸ σημεῖον αἱ ἴσαι κλασθήσονται ἐπὶ κύκλου γραμμῆς ἀεί. ἔστω γὰρ ἀπὸ τοῦ σημείου ἐφ' ᾧ τὸ Α πρὸς τὸ Β κεκλασμένη ᾗ τε τὸ ΑΓΒ καὶ ἡ τὸ ΑΖΒ καὶ ἡ τὸ ΑΔΒ· ἴσαι δὲ αὗταί τε αἱ ΑΓ ΑΖ ΑΔ ἀλλήλαις, καὶ αἱ πρὸς τὸ Β ἀλλήλαις, οἷον αἱ ΓΒ ΖΒ ΔΒ· καὶ ἐπεζεύχθω ἡ ΑΕΒ, ὥστε τὰ τρίγωνα ἴσα· καὶ γὰρ ἐπ' ἴσης τῆς ΑΕΒ. ἤχθωσαν δὴ κάθετοι ἐπὶ τὴν ΑΕΒ ἐκ τῶν γωνιῶν, ἀπὸ μὲν τῆς Γ ἡ τὸ ΓΕ, ἀπὸ δὲ τῆς Ζ ἡ τὸ ΖΕ, ἀπὸ δὲ τῆς Δ ἡ τὸ ΔΕ. ἴσαι δὴ αὗται· ἐν ἴσοις γὰρ τριγώνοις καὶ ἐν ἑνὶ ἐπιπέδῳ πᾶσαι· πρὸς ὀρθὰς γὰρ πᾶσαι τῇ ΑΕΒ, καὶ ἐφ' ἓν σημεῖον τὸ Ε συνάπτουσι. κύκλος ἄρα ἔσται ἡ γραφομένη, κέντρον δὲ τὸ Ε. ἔστι δὴ τὸ μὲν Β ὁ ἥλιος, τὸ δὲ Α ἡ ὄψις, ἡ δὲ περὶ

[1] seclusit Fobes.



To face p. 249]

the darkest of all in colour. But when it is broken it is a sign of wind; for its break up is due to a wind that is already in being but has not yet arrived. An indication that this is so is that the wind springs from the quarter in which the main break occurs. When it fades it is a sign of fine weather. For if the air is not yet in a state to overcome the heat contained in it and to develop into a watery condensation, it is clear that the vapour has not yet separated from the dry and fiery exhalation which causes fine weather.

These, then, are the atmospheric conditions in which reflection takes place. Our vision is reflected from the mist which condenses round the sun and moon; which is why a halo does not appear opposite the sun like a rainbow. And as the reflection is symmetrical on all sides, the result is bound to be a circle or a segment of a circle. For when lines drawn from the same point and to the same point are equal, the points at which they form an angle will always lie on a circle.[a] For let the lines AΓB, AZB and AΔB be drawn from the point A to the point B, each forming an angle: let the lines AΓ, AZ, AΔ be equal to each other, and the lines drawn to B, that is ΓB, ZB, ΔB, also equal to each other. Let the line AEB be drawn and the triangles so formed will be equal as they stand on the equal base AEB. Let perpendiculars be dropped from the angles to AEB, ΓE from Γ, ZE from Z, ΔE from Δ. These perpendiculars are then equal, being in equal triangles and in one plane. For all meet AEB at right angles and at the single point E. The figure thus drawn will be a circle with centre E. B is of course the sun, A the eye, and the

[a] Here Aristotle in effect assumes what he is setting out to prove.

373 a

τὸ ΓΖΔ περιφέρεια τὸ νέφος ἀφ' οὗ ἀνακλᾶται η ὄψις πρὸς τὸν ἥλιον.

Δεῖ δὲ νοεῖν συνεχῆ τὰ ἔνοπτρα ἀλλὰ διὰ μικρότητα ἕκαστον μὲν ἀόρατον, τὸ δ' ἐξ ἁπάντων ἓν εἶναι δοκεῖ διὰ τὸ ἐφεξῆς. φαίνεται δὲ τὸ μὲν λευκόν, ὁ ἥλιος, κύκλῳ συνεχῶς ἐν ἑκάστῳ φαινόμενος τῶν ἐνόπτρων, καὶ μηδεμίαν ἔχων αἰσθητὴν διαίρεσιν, πρὸς δὲ τῇ γῇ μᾶλλον διὰ τὸ νηνεμώτερον εἶναι· πνεύματος γὰρ ὄντος οὐκ εἶναι στάσιν φανερόν. παρὰ δὲ τοῦτο μέλαινα ἡ ἐχομένη περιφέρεια, διὰ τὴν ἐκείνης λευκότητα δοκοῦσα εἶναι μελαντέρα.

Πλεονάκις δὲ γίγνονται αἱ ἅλῳ περὶ τὴν σελήνην διὰ τὸ τὸν ἥλιον θερμότερον ὄντα θᾶττον διαλύειν τὰς συστάσεις τοῦ ἀέρος. περὶ δὲ τοὺς ἀστέρας γίγνονται μὲν διὰ τὰς αὐτὰς αἰτίας, οὐ σημειώδεις δ' ὁμοίως, ὅτι μικρὰς πάμπαν ἐπιδηλοῦσι τὰς συστάσεις καὶ οὔπω γονίμους.

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[a] Each particle thus reflecting colour only and not shape: 372 a 32.

[b] The O.T. would transpose these words, inserting them after the next sentence. It is not clear exactly where Aristotle

CHAPTER IV

ARGUMENT

The physical basis of reflection. Our vision is reflected from all smooth surfaces. Air reflects when condensed (sometimes even when not condensed): water reflects still better, and especially water in process of formation by condensation from air. Each particle of it forms a mirror, which reflects

circumference drawn through ΓΖΔ the cloud from which the vision is reflected to the sun.

Characteristics of the reflecting cloud.

The reflecting particles must be thought of as being continuous. Each individually is so small as to be invisible, but because they are continuous they appear in aggregate as a single surface. The bright light, that is, the sun, thus appears as a continuous ring, being mirrored in each of the reflecting particles as a point of light indivisible by sense [a] It appears in closer proximity to the earth because it is calmer there, and if there is a wind the halo cannot maintain its position [b] Next to the bright ring of the halo is a dark ring, which appears still darker beside the brightness of the halo

Haloes round the moon and stars

Haloes round the moon are more frequent than those round the sun because the sun being hotter more quickly dissolves the condensations of the air. They are formed round the stars from the same causes, but are not weather signs in the same way, because they indicate condensations that are insignificant and so not productive of weather changes.

does suppose that haloes form. *cf.* note on Aristotle's views of the stratification of the atmosphere at end of Book I. ch. 3.

CHAPTER IV

ARGUMENT (*continued*)

colour only, not shape · an agglomeration of particles forms a continuous mirror in which the colours mirrored by the constituent particles appear. So when sun and cloud are suitably related a rainbow is formed (373 a 32–b 32). *The rainbow is coloured, the halo not coloured because the rainbow*

is a reflection from water, the halo from air, and air (being light) cannot reflect colours, water (being dark) can Examples (373 b 32—374 b 7). The colours of the rainbow are due to the weakening of our sight by reflection This takes place in three stages · at the first the bright light of the sun, reflected in the dark medium of water, turns red further weakening of the sight produces green and then blue. These are the

373 a 32 Ἡ δ' ἶρις ὅτι μὲν ἐστιν ἀνάκλασις, εἴρηται πρότερον· ποία δὲ τις ἀνάκλασις, καὶ πῶς καὶ διὰ τίν' αἰτίαν ἕκαστα γίγνεται τῶν συμβαινόντων περὶ ταύτην, λέγωμεν νῦν.

35 Ἀνακλωμένη μὲν οὖν ἡ ὄψις ἀπὸ πάντων φαί-
373 b νεται τῶν λείων, τούτων δ' ἐστὶν καὶ ἀὴρ καὶ ὕδωρ. γίγνεται δὲ ἀπὸ μὲν ἀέρος, ὅταν τύχῃ συνιστάμενος. διὰ δὲ τὴν τῆς ὄψεως ἀσθένειαν πολλάκις καὶ ἄνευ συστάσεως ποιεῖ ἀνάκλασιν, οἷόν ποτε συνέβαινέ
5 τινι πάθος ἠρέμα καὶ οὐκ ὀξὺ βλέποντι· ἀεὶ γὰρ εἴδωλον ἐδόκει προηγεῖσθαι βαδίζοντι αὐτῷ, ἐξ ἐναντίας βλέπον πρὸς αὐτόν. τοῦτο δ' ἔπασχε διὰ τὸ τὴν ὄψιν ἀνακλᾶσθαι πρὸς αὐτόν· οὕτω γὰρ ἀσθενὴς ἦν καὶ λεπτὴ πάμπαν ὑπὸ τῆς ἀρρωστίας, ὥστ' ἔνοπτρον ἐγίγνετο καὶ ὁ πλησίον ἀήρ, καὶ οὐκ
10 ἐδύνατο ἀπωθεῖν—ὡς ὁ πόρρω καὶ πυκνός· διόπερ αἵ τ' ἄκραι ἀνεσπασμέναι φαίνονται ἐν τῇ θαλάττῃ, καὶ μείζω τὰ μεγέθη πάντων, ὅταν εὖροι πνέωσι, καὶ τὰ ἐν ταῖς ἀχλύσιν, οἷον καὶ ἥλιος καὶ ἄστρα ἀνίσχοντα καὶ δύνοντα μᾶλλον ἢ μεσοῦρανοῦντα.

Ἀπὸ δὲ ὕδατος μάλιστα ἀνακλᾶται, καὶ ἀπὸ
15 ἀρχομένου γίγνεσθαι μᾶλλον ἔτι ἢ ἀπ' ἀέρος· ἕκαστον γὰρ τῶν μορίων ἐξ ὧν γίγνεται συνισταμένων

three colours of the rainbow (374 b 7—375 a 7). *The yellow in the rainbow due to contrast of colours and not to reflection* (375 a 7-28) *The same causes account for the double rainbow ; in the outer of the two the order of colours is reversed. More than two rainbows are not seen at a time* (375 a 28–b 15).

It has already been stated that the rainbow is a reflection. We must now proceed to explain what kind of a reflection it is, how its various characteristics arise, and to what cause they are due.

How the rainbow is formed by reflection.

Our vision, then, is reflected from all smooth surfaces, among them air and water. Air reflects when it is condensed ; but even when not condensed it can produce a reflection when the sight is weak. An example of this is what used to happen to a man whose sight was weak and unclear : he always used to see an image going before him as he walked, and facing towards him. And the reason why this used to happen to him was that his vision was reflected back to him ; for its enfeebled state made it so weak and faint that even the neighbouring air became a mirror and it was unable to thrust it aside. Distant and dense air does of course normally act as a mirror in this way, which is why when there is an east wind promontories on the sea appear to be elevated above it and everything appears abnormally large [a] ; the same is true of objects seen in a mist, or twilight—for instance the sun and stars which at their rising and setting appear larger than at their meridian.

But reflection takes place chiefly from water, and still better from water in process of formation than from air : for each of the particles which when con-

[a] It is not clear exactly how Aristotle supposed this effect to be produced : *cf. Problems* xxvi. 53.

373 b ἡ ψακὰς ἔνοπτρον ἀναγκαῖον εἶναι μᾶλλον τῆς ἀχλύος. ἐπεὶ δὲ καὶ δῆλον καὶ εἴρηται πρότερον ὅτι ἐν τοῖς τοιούτοις ἐνόπτροις τὸ χρῶμα μόνον ἐμφαίνεται, τὸ δὲ σχῆμα ἄδηλον, ἀναγκαῖον, ὅταν ἄρχηται ὑγρὸν εἶναι καὶ ἤδη μὲν συνιστῆται εἰς ψακάδας ὁ ἐν τοῖς νέφεσιν ἀήρ, μήπω δὲ ὗῃ, ἐὰν ἐξ ἐναντίας ᾖ ὁ ἥλιος ἢ ἄλλο τι οὕτω λαμπρὸν ὥστε γίγνεσθαι ἔνοπτρον τὸ νέφος, καὶ τὴν ἀνάκλασιν γίγνεσθαι πρὸς τὸ λαμπρὸν ἐξ ἐναντίας, γίγνεσθαι ἔμφασιν χρώματος, οὐ σχήματος. ἑκάστου δ' ὄντος τῶν ἐνόπτρων μικροῦ καὶ ἀοράτου, τῆς δ' ἐξ ἁπάντων αὐτῶν συνεχείας τοῦ μεγέθους ὁρωμένης, ἀνάγκη συνεχὲς μέγεθος τοῦ αὐτοῦ φαίνεσθαι χρώματος· ἕκαστον γὰρ τῶν ἐνόπτρων τὸ αὐτὸ ἀποδίδωσι χρῶμα τῷ συνεχεῖ. ὥστ' ἐπεὶ ταῦτ' ἐνδέχεται συμβαίνειν, ὅταν τοῦτον ἔχῃ τὸν τρόπον ὅ τε ἥλιος καὶ τὸ νέφος καὶ ἡμεῖς ὦμεν μεταξὺ αὐτῶν, ἔσται διὰ τὴν ἀνάκλασιν ἔμφασίς τις. ἀλλὰ μὴν καὶ φαίνεται τότε καὶ οὐκ ἄλλως ἐχόντων γιγνομένη ἡ ἶρις.

Ὅτι μὲν οὖν ἀνάκλασις ἡ ἶρις τῆς ὄψεως πρὸς τὸν ἥλιόν ἐστι, φανερόν· διὸ καὶ ἐξ ἐναντίας ἀεὶ γίγνεται, ἡ δ' ἄλως περὶ αὐτόν· καίτοι ἄμφω ἀνά- 374 a κλασις· ἀλλ' ἥ γε τῶν χρωμάτων ποικιλία διαφέρει· ἡ μὲν γὰρ ἀφ' ὕδατος καὶ μέλανος γίγνεται ἀνάκλασις καὶ πόρρωθεν, ἡ δ' ἐγγύθεν καὶ ἀπὸ ἀέρος λευκοτέρου τὴν φύσιν.

Φαίνεται δὲ τὸ λαμπρὸν διὰ τοῦ μέλανος ἢ ἐν τῷ μέλανι (διαφέρει γὰρ οὐδέν) φοινικοῦν (ὁρᾶν δ'

[a] 372 a 32.

densed forms a raindrop will necessarily be a better mirror than mist. Now it is clear, and has already [a] been stated, that in mirrors of this kind colour only is reflected and shape does not appear When, therefore, it is about to rain and the air in the clouds is already condensing into raindrops but the rain is not yet falling, if there is, opposite the cloud, the sun or any other object so bright that the cloud mirrors it and reflection takes place from the cloud to the bright object opposite, an image of colour but not of shape must be produced. Each of the reflecting particles is invisibly small, and the continuous magnitude formed by them all is what we see ; what appears to us is therefore necessarily a continuous magnitude of a single colour, since each of the reflecting particles gives off a colour the same as that of the continuous whole. Since, therefore, these conditions are theoretically possible, we may suppose that when the sun and the cloud stand in this relation and we are situated between them, the process of reflection will give rise to an image. And it is under these conditions and no others that the rainbow in fact appears.

It is clear, then, that the rainbow is a reflection of our sight to the sun. And so the rainbow is always opposite the sun, the halo round it. Both are reflections, but the variety of its colours distinguishes the rainbow, which is a reflection from a distance and from water that is dark, while the halo is a reflection from near by and from air which is naturally lighter.

Bright light shining through a dark medium or reflected in a dark surface (it makes no difference which) looks red.[b] Thus one can see how the flames

[b] *De Sensu* 440 a 10, *De Col.* ch. 2, 792 a 8 ff.

374 a ἔξεστι τό γε τῶν χλωρῶν ξύλων πῦρ, ὡς ἐρυθρὰν ἔχει τὴν φλόγα διὰ τὸ τῷ καπνῷ πολλῷ μεμεῖχθαι τὸ πῦρ λαμπρὸν ὂν καὶ λευκόν)· καὶ δι' ἀχλύος καὶ καπνοῦ ὁ ἥλιος φαίνεται φοινικοῦς. διὸ ἡ μὲν τῆς ἴριδος ἀνάκλασις ἡ μὲν πρώτη τοιαύτην ἔχειν φαίνεται τὴν χρόαν (ἀπὸ ῥανίδων γὰρ μικρῶν γίγνεται ἡ ἀνάκλασις), ἡ δὲ τῆς ἅλω οὔ. περὶ δὲ τῶν ἄλλων χρωμάτων ὕστερον ἐροῦμεν. ἔτι δὲ περὶ αὐτὸν μὲν τὸν ἥλιον οὐ γίγνεται διατριβὴ τοιαύτης συστάσεως, ἀλλ' ἢ ὕει ἢ διαλύεται. ἐκ δὲ τῶν ἐναντίων ἐν τῷ μεταξὺ τῆς τοῦ ὕδατος γενέσεως γίγνεταί τις χρόνος· τούτου γὰρ μὴ συμβαίνοντος ἦσαν ἂν κεχρωματισμέναι αἱ ἅλως ὥσπερ ἡ ἶρις. νῦν δ' ὅλα μὲν οὐ γίγνεται τοιαύτην ἔχοντα τὴν ἔμφασιν, οὐδὲ κύκλῳ, μικρὰ δὲ καὶ κατὰ μόριον, αἳ καλοῦνται ῥάβδοι, ἐπεὶ εἰ συνίστατο τοιαύτη ἀχλὺς οἵα γένοιτ' ἂν ὕδατος ἢ τινος ἄλλου μέλανος, καθάπερ λέγομεν, ἐφαίνετο ἂν ἡ ἶρις ὅλη, ὥσπερ ἡ περὶ τοὺς λύχνους. περὶ γὰρ τούτους τὰ πλεῖστα νοτίων ὄντων ἶρις γίγνεται τοῦ χειμῶνος, μάλιστα δὲ δήλη γίγνεται τοῖς ὑγροὺς ἔχουσι τοὺς ὀφθαλμούς. τούτων γὰρ ἡ ὄψις ταχὺ δι' ἀσθένειαν ἀνακλᾶται. γίγνεται δ' ἀπό τε τῆς τοῦ ἀέρος ὑγρότητος καὶ ἀπὸ λιγνύος τῆς ἀπὸ τῆς φλογὸς ἀπορρεούσης καὶ μειγνυμένης· τότε γὰρ γίγνεται ἔνοπτρον,[1] καὶ διὰ τὴν μελανίαν· καπνώδης γὰρ ἡ λιγνύς· τὸ δὲ τοῦ λύχνου φῶς οὐ λευκὸν ἀλλὰ πορφυροῦν φαίνεται κύκλῳ καὶ ἰριῶδες, φοινικοῦν δ' οὔ· ἔστι

[1] τότε . ἔνοπτρον interclusionem distinguit Thurot.

And water is dark.

of a fire made of green wood are red, because the fire-light which is bright and clear is mixed with a great deal of smoke; and the sun looks red when seen through mist or smoke. The reflection which is the rainbow therefore has its outermost circumference of this colour, since the reflection is from minute water-drops [a]; but in the halo this colour does not appear. With the other colours we will deal later. Further, a condensation of this kind does not linger long round the sun itself, but either turns to rain or disperses . but during the formation of water opposite the sun some time elapses. If this were not so haloes would be coloured like the rainbow. As it is, no complete or circular halo presents this appearance, but only the small, partial formations called "rods"; for if a formation of the kind of mist which arises from water or any other dark substance in the way we maintain [b] were present, we should see a complete rainbow, like the one we see round lamps. For a rainbow does form round lamps in the winter, especially when there is a south wind, and is most clearly visible to those whose eyes are watery, for their sight is weak and so easily reflected. The rainbow is due to the moisture of the air and to the soot which is given off by and mixed with the flame, and so forms a mirror owing to the dark colour derived from the smokiness of the soot [c]: and the light of the lamp appears not white but purple, and forms a ring like a rainbow, except that the colour red is

[b] a 1 above: the rainbow is a reflection in a dark medium.

[c] Or take *τότε γὰρ γίνεται ἔνοπτρον* (l. 25) as a parenthesis, and the meaning is that the rainbow is due to moisture, to soot and the dark colour derived from the soot, which between them constitute the mirror. But Alex. seems to have had a text punctuated as that printed here.

374 a
γὰρ ἥ τε ὄψις ὀλίγη ἡ ἀνακλωμένη, καὶ μέλαν τὸ
30 ἔνοπτρον. ἡ δ' ἀπὸ τῶν κωπῶν τῶν ἀναφερομένων
ἐκ τῆς θαλάττης ἶρις τῇ μὲν θέσει τὸν αὐτὸν γί-
γνεται τρόπον τῇ ἐν τῷ οὐρανῷ, τὸ δὲ χρῶμα
ὁμοιοτέρα τῇ περὶ τοὺς λύχνους· οὐ γὰρ φοινικῆν
ἀλλὰ πορφυρᾶν ἔχουσα φαίνεται τὴν χρόαν. ἡ δ'
ἀνάκλασις ἀπὸ τῶν μικροτάτων μὲν συνεχῶν δὲ
35 γίγνεται ῥανίδων· αὗται δ' ὕδωρ ἀποκεκριμένον
374 b εἰσὶν ἤδη παντελῶς. γίγνεται δὲ κἂν τις λεπταῖς
ῥαίνῃ ῥανίσιν εἴς τι τοιοῦτον χωρίον ὃ τὴν θέσιν
πρὸς τὸν ἥλιον ἐστραμμένον ἐστὶ καὶ τῇ μὲν ὁ ἥλιος
ἀνέχῃ τῇ δὲ σκιάζῃ· ἐν τῷ τοιούτῳ γάρ, ἐὰν εἴσω
τις ῥαίνῃ, τῷ ἑστῶτι ἐκτός, ᾗ ἐπαλλάττουσιν αἱ
5 ἀκτῖνες καὶ ποιοῦσι τὴν σκιάν, φαίνεται ἶρις. ὁ
δὲ τρόπος καὶ ἡ χρόα ὁμοία καὶ τὸ αἴτιον τὸ αὐτὸ
τῇ ἀπὸ τῶν κωπῶν· τῇ γὰρ χειρὶ κώπῃ χρῆται
ὁ ῥαίνων.

Ὅτι δὲ τὸ χρῶμα τοιοῦτον, ἅμα δῆλον ἔσται καὶ
περὶ τῶν ἄλλων χρωμάτων τῆς φαντασίας, ἐκ
τῶνδε. δεῖ γὰρ νοήσαντας, ὥσπερ εἴρηται, καὶ
10 ὑποθεμένους πρῶτον μὲν ὅτι τὸ λαμπρὸν ἐν τῷ
μέλανι ἢ διὰ τοῦ μέλανος χρῶμα ποιεῖ φοινικοῦν,
δεύτερον δ' ὅτι ἡ ὄψις ἐκτεινομένη ἀσθενεστέρα
γίγνεται καὶ ἐλάττων, τρίτον δ' ὅτι τὸ μέλαν οἷον
ἀπόφασίς ἐστιν· τῷ γὰρ ἐκλείπειν τὴν ὄψιν φαίνεται
μέλαν· διὸ τὰ πόρρω πάντα μελάντερα φαίνεται,
15 διὰ τὸ μὴ διικνεῖσθαι τὴν ὄψιν. θεωρείσθω μὲν
οὖν ταῦτ' ἐκ τῶν περὶ τὰς αἰσθήσεις συμβαινόντων·
ἐκείνων γὰρ ἴδιοι οἱ περὶ τούτων λόγοι· νῦν δ' ὅσον

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[a] " It is bound to be weak by lamplight " (O.T.).
[b] 372 a 1, ch. 2 above.

missing, as the reflected vision is weak[a] and the mirror dark. The rainbow produced by oars breaking water is the outcome of the same relative positions as a rainbow in the sky but is more like the rainbow round a lamp in colour, since it appears purple and not red The reflection takes place from a number of minute water-drops which form between them a continuous surface, and which are of course water already fully formed. A rainbow is also produced when someone sprinkles a fine spray into a room so placed that it faces the sun and is partly illuminated by it, partly in shadow. When anyone sprinkles water inside a room so placed a rainbow appears, to anyone standing outside, at the point where the sun's rays stop and the shadow begins. It arises in the same way as the rainbow produced by the oars, is similar to it in colour and due to the same cause, for the sprinkler uses his hand like an oar.

The following considerations will make clear both that the colours of the rainbow are such as we have described[b] and how the other colours appear in it. We must, as has been said,[c] bear in mind and assume the following principles. (1) White light reflected on a dark surface or passing through a dark coloured medium produces red; (2) our vision becomes weaker and less effective with distance; (3) dark colour is a kind of negation of vision, the appearance of darkness being due to the failure of our sight; hence objects seen at a distance appear darker because our sight fails to reach them. These principles should be examined in the light of the processes of sensation, and the discussion of them properly belongs to the theory of sensation; here let us say no more about

Cf. 373 b 9, 374 a 3.

374 b ἀνάγκη, τοσοῦτον περὶ αὐτῶν λέγωμεν. φαίνεται δ' οὖν διὰ ταύτην τὴν αἰτίαν τά τε πόρρω μελάντερα καὶ ἐλάττω καὶ λειότερα, καὶ τὰ ἐν τοῖς ἐνόπτροις, καὶ τὰ νέφη μελάντερα βλέπουσιν εἰς τὸ ὕδωρ ἢ εἰς αὐτὰ τὰ νέφη. καὶ τοῦτο πάνυ ἐπιδήλως· διὰ γὰρ τὴν ἀνάκλασιν ὀλίγῃ τῇ ὄψει θεωροῦνται. διαφέρει δ' οὐδὲν τὸ ὁρώμενον μεταβάλλειν ἢ τὴν ὄψιν· ἀμφοτέρως γὰρ ἔσται ταὐτόν. πρὸς δὲ τούτοις δεῖ μὴ λελῆθέναι καὶ τόδε· συμβαίνει γὰρ ὅταν ᾖ τοῦ ἡλίου νέφος πλησίον, εἰς μὲν αὐτὸ βλέποντι μηδὲν φαίνεσθαι κεχρωματισμένον ἀλλ' εἶναι λευκόν, ἐν δὲ τῷ ὕδατι αὐτὸ τοῦτο θεωροῦντι χρῶμά τι ἔχειν τῆς ἴριδος. δῆλον τοίνυν ὅτι ἡ ὄψις ὥσπερ καὶ τὸ μέλαν κλωμένη δι' ἀσθένειαν μελάντερον ποιεῖ φαίνεσθαι, καὶ τὸ λευκὸν ἧττον λευκόν, καὶ προσάγει πρὸς τὸ μέλαν. ἡ μὲν οὖν ἰσχυροτέρα ὄψις εἰς φοινικοῦν χρῶμα μετέβαλεν, ἡ δ' ἐχομένη εἰς τὸ πράσινον, ἡ δὲ ἔτι ἀσθενεστέρα εἰς τὸ ἁλουργόν. ἐπὶ δὲ τὸ πλέον οὐκέτι φαίνεται, ἀλλ' ἐν τοῖς τρισίν, ὥσπερ καὶ τῶν ἄλλων τὰ πλεῖστα, καὶ τούτων ἔσχεν τέλος· τῶν δ' ἄλλων ἀναίσθητος
375 a ἡ μεταβολή. διὸ καὶ ἡ ἶρις τρίχρως φαίνεται, ἑκατέρα μέν, ἐναντίως δέ. ἡ μὲν οὖν πρώτη τὴν ἔξω φοινικῆν ἔχει· ἀπὸ μεγίστης γὰρ περιφερείας πλείστη προσπίπτει ὄψις πρὸς τὸν ἥλιον, μεγίστη δ' ἡ ἔξω· ἡ δ' ἐχομένη καὶ ἡ τρίτη ἀνάλογον. ὥστ' εἰ τὰ περὶ τῶν χρωμάτων τῆς φαντασίας εἴρηται καλῶς, ἀνάγκη τρίχρων τε εἶναι αὐτὴν καὶ τούτοις

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[a] "i.e. whether the object is actually further from the eye in space or whether (owing to reflection) the sight travels to it by a longer route" (O.T.). [b] *Cf. De Caelo* 268 a 9 ff.
[c] *i.e.* inner, *cf.* 375 b 6. [d] 374 b 9.

them than is necessary for our present purpose. At any rate, they give the reason why distant objects appear darker and smaller and less irregular, as do also objects seen in mirrors, and why too the clouds appear darker when one looks at their reflection in water than directly at them. This last example is a particularly clear one. for we view them with a vision diminished by the reflection. And it makes no difference whether the change is in the object or in our vision [a]; the result is the same in either case. The following fact also must not be overlooked; when a cloud is close to the sun, when we look directly at it, it appears to have no colour but to be white, but when we look at its reflection in water it seems to be partially rainbow-coloured. The reason is clearly that, just as our vision when reflected through an angle and so weakened makes a dark colour appear still darker, so also it makes white appear less white and approach nearer to black. When the sight is fairly strong the colour changes to red, when it is less strong to green, and when it is weaker still to blue. There is no further change of colour, the complete process consisting, like most others,[b] of three stages; any further change is imperceptible. This is why the rainbow is three-coloured, and why, when there are two of them, each is three-coloured, but the colours are in the reverse order in each. In the primary [c] rainbow the outermost band is red. For the vision is reflected most strongly on to the sun from the largest circumference, and the outermost band is the largest: and corresponding remarks apply to the second and third bands. So if our assumptions [d] about the appearance of colours are correct, the rainbow must be three-coloured and its only colours must be these three.

375 a

τοῖς χρώμασι κεχρῶσθαι μόνοις. τὸ δὲ ξανθὸν φαίνεται διὰ τὸ παρ' ἄλληλα φαίνεσθαι. τὸ γὰρ φοινικοῦν παρὰ τὸ πράσινον λευκὸν φαίνεται. σημεῖον δὲ τούτου· ἐν γὰρ τῷ μελαντάτῳ νέφει μάλιστα ἄκρατος γίγνεται ἶρις συμβαίνει δὲ τότε ξανθότερον εἶναι δοκεῖν τὸ φοινικοῦν. ἔστι δὲ τὸ ξανθὸν ἐν τῇ ἴριδι χρῶμα μεταξὺ τοῦ τε φοινικοῦ καὶ πρασίνου χρώματος.[1] διὰ τὴν μελανίαν οὖν τοῦ κύκλῳ νέφους ὅλον αὐτοῦ φαίνεται τὸ φοινικοῦν λευκόν· ἔστι γὰρ πρὸς ἐκεῖνα[2] λευκόν. καὶ πάλιν ἀπομαραινομένης τῆς ἴριδος [ἐγγύτατα],[3] ὅταν λύηται τὸ φοινικοῦν· ἡ γὰρ νεφέλη λευκὴ οὖσα, προσπίπτουσα παρὰ τὸ πράσινον, μεταβάλλει εἰς τὸ ξανθόν. μέγιστον δὲ σημεῖον τούτων ἡ ἀπὸ τῆς σελήνης ἶρις· φαίνεται γὰρ λευκὴ πάμπαν. γίγνεται δὲ τοῦτο ὅτι ἔν τε τῷ νέφει ζοφερῷ φαίνεται καὶ ἐν νυκτί. ὥσπερ οὖν πῦρ ἐπὶ πῦρ, μέλαν παρὰ μέλαν ποιεῖ τὸ ἠρέμα λευκὸν παντελῶς φαίνεσθαι λευκόν· τοῦτο δ' ἐστὶν τὸ φοινικοῦν. γίγνεται δὲ τοῦτο τὸ πάθος καταφανὲς καὶ ἐπὶ τῶν ἀνθῶν· ἐν γὰρ τοῖς ὑφάσμασιν καὶ ποικίλμασιν ἀμύθητον διαφέρει τῇ φαντασίᾳ ἄλλα παρ' ἄλλα τιθέμενα τῶν

[1] ἔστι . . . χρώματος post φαίνεται l. 8 fortasse tranciendum : post μόνοις l. 7 coll. Thurot, et pro τὸ δὲ ξανθὸν φαίνεται cl. φαίνεται δὲ.
[2] ἐκεῖνο E_{corr} N_{rec}
[3] ἐγγύτατα seclusi : om. E_1 Ap Ol O.T.

[a] In what follows (ll. 7-17), Aristotle is trying to account for the orange colour in the rainbow. This he regards as due not to reflection, like its other three colours, but to the contrast of two colours in juxtaposition. The argument of the passage is not easy to follow in detail. What seems certain is that Aristotle is trying to explain two things : (i) the occurrence of a yellow band *between* the red and the green ; this he has already noticed (372 a 9) and refers to here (ll. 11-12) ;

The yellow colour[a] that appears in the rainbow is due to the contrast of two others; for red in contrast to green appears light. (And the yellow colour in the rainbow lies between the red and green.)[a] An example of such contrast is the fact that the rainbow is purest when the cloud is blackest, and that in these circumstances the red appears more yellow. So the whole of the red appears light because of the contrast with the blackness of the surrounding cloud; for compared with the cloud it is light-coloured. The same thing happens when the rainbow is fading and the red dissolving for the cloud, which is white, changes to yellow when brought next to the green.[b] But the best illustration of colour contrast is afforded by the moon rainbow. This appears entirely white, simply because it appears in dark cloud and at night. For as fire increases fire,[c] so dark placed by dark makes a dim light (like red) appear clear and bright. The same effect can also be seen in dyes: for there is an indescribable difference in the appearance of the colours in woven or embroidered materials when

(ii) the replacement of the red band by a yellow, which is apparently what he has in mind in ll. 10-14 and certainly what he has in mind in ll. 14-16 (see note *b*). As Thurot pointed out, the sentence *ἔστι δέ . . . χρώματος* (ll. 11-12) in its present position breaks the sequence of thought. I have suggested that it would come more naturally after *φαίνεται* (l. 8) and translated accordingly. Aristotle thus starts by accounting for the yellow *between* green and red by colour contrast, and then goes on (l. 9 *σημεῖον δὲ τούτου, sc. τοῦ παρ' ἄλληλα φαίνεσθαι*) to give further examples of such contrast in which the whole of the red is *replaced* by yellow. *ἐκεῖνο* should then be read for *ἐκεῖνα* in l 14.

[b] When the rainbow fades the red disappears first. It is to this that Aristotle refers here when he speaks of a yellow band replacing the red as a result of colour contrast.

[c] Proverbial.

375 a χρωμάτων, οἷον καὶ τὰ πορφυρᾶ ἐν λευκοῖς ἢ μέλασιν ἐρίοις, ἔτι δ' ἐν αὐγῇ τοιᾳδὶ ἢ τοιᾳδί· διὸ καὶ οἱ ποικιλταί φασι διαμαρτάνειν ἐργαζόμενοι πρὸς τὸν λύχνον πολλάκις τῶν ἀνθῶν, λαμβάνοντες ἕτερα ἀνθ' ἑτέρων.

Διότι μὲν οὖν τρίχρως τε, καὶ ὅτι ἐκ τούτων
30 φαίνεται τῶν χρωμάτων μόνων ἡ ἶρις, εἴρηται. διπλῆ[1] δὲ καὶ ἀμαυροτέρα τοῖς χρώμασιν ἡ περιέχουσα, καὶ τῇ θέσει τὰς χρόας ἐξ ἐναντίας ἔχει κειμένας διὰ τὴν αὐτὴν αἰτίαν· μακροτέρα γὰρ ἀποτεινομένη ἡ ὄψις ὥσπερ τὸ πορρώτερον ὁρᾷ, καὶ τὸ ἐνταῦθα τὸν αὐτὸν τρόπον. ἀσθενεστέρα οὖν
375 b ἀπὸ τῆς ἔξωθεν ἡ ἀνάκλασις γίγνεται διὰ τὸ πορρώτερον ποιεῖσθαι τὴν ἀνάκλασιν, ὥστ' ἐλάττων προσπίπτουσα τὰ χρώματα ποιεῖ ἀμαυρότερα φαίνεσθαι. καὶ ἀντεστραμμένως δὴ διὰ τὸ πλείω ἀπὸ
5 τῆς ἐλάττονος καὶ τῆς ἐντὸς περιφερείας προσπίπτειν πρὸς τὸν ἥλιον· ἐγγυτέρω γὰρ τῆς ὄψεως οὖσα ἀνακλᾶται ἀπὸ τῆς ἐγγυτάτω περιφερείας τῆς πρώτης ἴριδος. ἐγγυτάτω δὲ ἐν τῇ ἔξωθεν ἴριδι ἡ ἐλαχίστη περιφέρεια, ὥστε αὕτη ἕξει τὸ χρῶμα φοινικοῦν· ἡ δ' ἐχομένη καὶ ἡ τρίτη κατὰ λόγον.

[1] *διπλῆς* ci. Thurot.

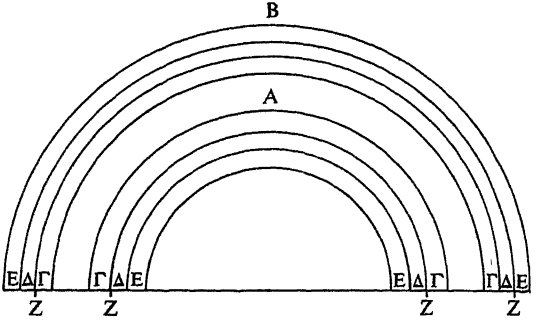
they are differently arranged, for instance, purple is quite different on a white or a black background, and variations of light can make a similar difference. So embroiderers say they often make mistakes in their colours when they work by lamplight, picking out one colour in mistake for another.

This, then, is why the rainbow is three-coloured and why the rainbow is made up of these three colours only. The same cause accounts for the double rainbow and for the colours in the outer bow being dimmer and in the reverse order. For the effects here are the same as those produced by an increase in the distance of vision on our perception of distant objects.[a] The reflection from the outer rainbow is weaker because it has farther to travel; its impulse is therefore feebler, which makes the colours seem dimmer. The colours are in the reverse order because the impulse reaching the sun is greater from the smaller and inner band; for the reflection that is closer to our sight is the one reflected from the band that is closest to the primary rainbow, that is, the smallest band in the outer rainbow, which will consequently be coloured red. And the second and third bands are to be explained analogously.

[a] *Cf.* 374 b 9 ff.

375 b

Ἡ ἔξω ἶρις ἐφ' ᾧ τὸ Β· ἡ ἔσω, ἡ πρώτη, ἐφ' ᾧ τὸ Α· τὰ χρώματα δ', ἐφ' ᾧ τὸ Γ, φοινικοῦν, ἐφ' ᾧ τὸ Δ, πράσινον, ἐφ' ᾧ Ε, ἁλουργόν· τὸ ξανθὸν δὲ φαίνεται ἐφ' οὗ τὸ Ζ.



Τρεῖς δ' οὐκέτι γίγνονται, οὐδὲ πλείους ἶριδες, διὰ τὸ καὶ τὴν δευτέραν γίγνεσθαι ἀμαυροτέραν, ὥστε καὶ τὴν τρίτην ἀνάκλασιν πάμπαν ἀσθενῆ γίγνεσθαι καὶ ἀδυνατεῖν ἀφικνεῖσθαι πρὸς τὸν ἥλιον.

CHAPTER V

ARGUMENT

(*I*) *Demonstration that when the sun is on the horizon the rainbow cannot be greater than a semicircle* (375 b 16—376 b 22). (*II*) *Demonstration that when the sun is above the horizon the rainbow must be less than a semicircle* (376 b 28—377 a 11). (*III*) *The differences in the size of the sun's arc above the horizon account for the fact that rainbows do not occur at midday in the summer months* (377 a 11-28).

Let B be the outer and A the inner, primary rainbow : and to symbolize the colours, let us use Γ for red, Δ for green, E for purple. Yellow will appear at Z.

Three or more rainbows are never seen, because even the second is dimmer than the first, and so the third reflection is altogether too feeble to reach the sun.

CHAPTER V

ARGUMENT (*continued*)

Note.—*The general intention of these geometrical demonstrations is clear. In the first the eye is imagined to be at the centre K of the horizon* (*Fig.* 1) *: the lines of vision form a cone with apex K and base the circle MMM. The sun or other heavenly body is imagined to be rising on the horizon at H. Then MMM is the rainbow. It is evident at once that in the limiting case represented by the figure the rainbow will be a*

figure can be drawn for other seasons with the sun's course shown as a segment greater or less than a semicircle. And this variation of the arc accounts for the fact that whereas in the shorter days rainbows occur at any time of day, during the longer days they cannot occur at midday.

It will be clear from a study of the diagram that the rainbow can never be a complete circle or a segment of a circle greater than a semicircle; the diagram will also make clear its other properties.

(I) (1) Let A be a hemisphere resting on the circle of the horizon whose centre is K: let H be another point rising on the horizon. If the lines that fall in a cone from K rotate about HK as an axis, and if lines Demonstration (I).

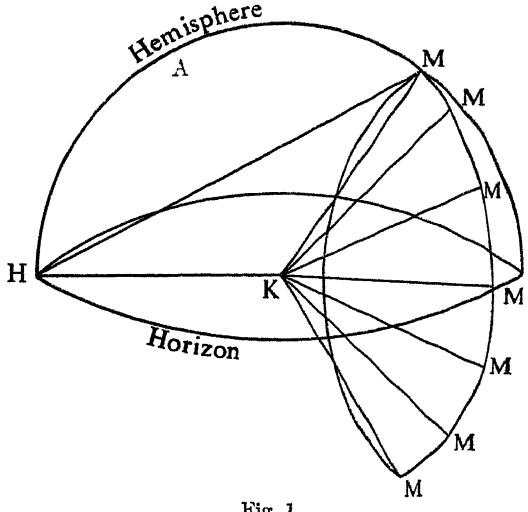


Fig 1

375 b τὸ Μ ἐπιζευχθεῖσαι ἀνακλασθῶσιν ἀπὸ τοῦ ἡμισφαιρίου ἐπὶ τὸ Η ἐπὶ τὴν μείζω γωνίαν, πρὸς
25 κύκλου περιφέρειαν προσπεσοῦνται αἱ ἀπὸ τοῦ Κ· καὶ ἐὰν μὲν ἐπ' ἀνατολῆς ἡ ἐπὶ δύσεως τοῦ ἄστρου ἡ ἀνάκλασις γένηται, ἡμικύκλιον ἀποληφθήσεται τοῦ κύκλου ὑπὸ τοῦ ὁρίζοντος τὸ ὑπὲρ γῆν γιγνόμενον, ἐὰν δ' ἐπάνω, ἀεὶ ἔλαττον ἡμικυκλίου· ἐλάχιστον δέ, ὅταν ἐπὶ τοῦ μεσημβρινοῦ γένηται τὸ
30 ἄστρον.

Ἔστω γὰρ ἐπ' ἀνατολῆς πρῶτον, οὗ τὸ Η, καὶ ἀνακεκλάσθω ἡ ΚΜ ἐπὶ τὸ Η, καὶ τὸ ἐπίπεδον

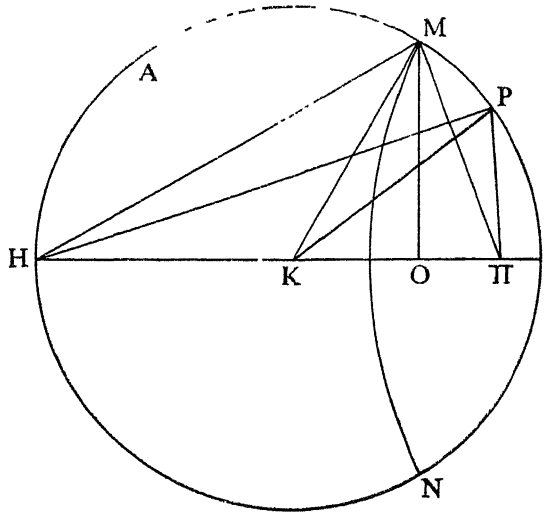


Fig. 2

drawn joining K and M are reflected (at M) from the surface of the hemisphere back to H over the obtuse angle (HKM), the lines from K fall on the circumference of a circle. If the reflection takes place at the rising or setting of a heavenly body, the segment of the circle cut off above the earth by the horizon will be a semicircle ; if the body has risen higher, the segment will be less than a semicircle, and it will be smallest when the body reaches its meridian.

(2) For let the heavenly body be just rising at the point H, and let the line KM be reflected to H, and

375 b ἐκβεβλήσθω [ἐν ᾧ ἡ A,][1] τὸ ἀπὸ τοῦ τριγώνου ἐν ᾧ[2] τὸ HKM. κύκλος οὖν ἡ τομὴ ἔσται τῆς σφαίρας ὁ μέγιστος. ἔστω ὁ ἐφ' ᾧ Α· διοίσει γὰρ οὐδὲν ἂν ὁποιονοῦν τῶν ἐπὶ τῆς HK κατὰ τὸ
376 a τρίγωνον τὸ KMH ἐκβληθῇ τὸ ἐπίπεδον. αἱ οὖν ἀπὸ τῶν H K ἀναγόμεναι γραμμαὶ ἐν τούτῳ τῷ λόγῳ οὐ συσταθήσονται τοῦ ἐφ' ᾧ A ἡμικυκλίου πρὸς ἄλλο καὶ ἄλλο σημεῖον· ἐπεὶ γὰρ τά τε K H
5 σημεῖα δέδοται καὶ ἡ HK, δεδομένη ἂν εἴη καὶ ἡ MH, ὥστε καὶ λόγος τῆς MH πρὸς MK. δεδομένης οὖν περιφερείας ἐφάψεται τὸ M. ἔστω δὴ αὕτη ἐφ' ἧς τὰ N M· ὥστε ἡ τομὴ τῶν περιφερειῶν δέδοται. πρὸς ἄλλῃ δέ γε ἢ τῇ MN περιφερείᾳ ἀπὸ τῶν αὐτῶν σημείων ὁ αὐτὸς λόγος ἐν τῷ αὐτῷ ἐπιπέδῳ οὐ συνίσταται.
10 Ἐκκείσθω οὖν τις γραμμὴ ἡ ΔB, καὶ τετμήσθω ὡς ἡ MH πρὸς MK ἡ Δ πρὸς B. μείζων δὲ ἡ MH τῆς KM, ἐπείπερ ἐπὶ τὴν μείζω γωνίαν ἡ ἀνάκλασις τοῦ κώνου· ὑπὸ γὰρ τὴν μείζω γωνίαν ὑποτείνει τοῦ KMH τριγώνου. [μείζων ἄρα καὶ ἡ Δ τῆς B.][3]
15 προσπεπορίσθω οὖν πρὸς τὴν B, ἐφ' ἧς τὸ Z· ὥστ' εἶναι ὅπερ τὴν Δ πρὸς τὴν B, τὴν BZ πρὸς τὴν Δ. εἶτα ὅπερ ἡ Z πρὸς τὴν KH, ἡ τὸ B πρὸς ἄλλην πεποιήσθω τὴν KΠ, καὶ ἀπὸ τοῦ Π ἐπὶ τὸ M ἐπεζεύχθω ἡ τὸ MΠ. ἔσται οὖν τὸ Π πόλος τοῦ κύ-

[1] seclusi : scilicet A posuit hemisphaerium supra ll. 19, 20.
[2] ἐφ' ᾧ ci. O.T.
[3] μείζων . . . τῆς B secl Fobes : habent E_{corr} F_{corr} H N.

[a] I have omitted the words ἐν ᾧ ἡ A since A has so far only occurred as a hemisphere (ll. 19-20), and so to speak of it lying on a plane is nonsense. Sense can only be made of the words by supposing that A refers here to something else (*e.g.* "a

let the plane of the triangle HKM be produced [a] It will cut the sphere in a great circle : let this be called A. (It makes no difference which of the planes passing through HK and determined by the triangle KMH is produced) Then lines drawn from the points H and K to any point on the semicircle A other than M will not bear the same relation to each other (as HM and KM). For if the points K and H and the line HK are given, the line MH will be given too, and so the ratio of MH to MK. The point on M thus touches a given circumference, which we will call NM, and so the intersection of the two circumferences [b] is given. But the same ratio will not hold between lines drawn from the same points H and K and in the same plane to any circumference other than MN.

(3) Draw a line ΔB outside the figure, and divide

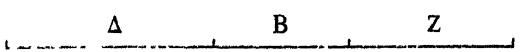


Fig. 3

it into two parts Δ and B in the ratio MH : MK. MH is greater than MK since the reflection of the cone is over the greater angle, subtending the greater angle of the triangle KMH. [Δ is therefore greater than B.] Produce the line B to form a line Z, so that B + Z has the same ratio to Δ as Δ has to B. Produce HK to Π so that B has the same ratio to KΠ as Z to KH. Join Π and M to form the line MΠ. Π will

great circle of the whole sphere" (O.T.)). But Alex. does not seem to have had the words, and the passage makes better sense without them.

[b] *i.e.* of the great circle formed by producing the plane of the triangle HKM and called A (l. 375 b 33) and the circle forming the base of the cone (MMM Fig. 1).

κλου, πρὸς ὃν αἱ ἀπὸ τοῦ Κ γραμμαὶ προσπίπτουσιν·
ἔσται γὰρ ὅπερ ἡ Ζ πρὸς ΚΗ, καὶ ἡ Β πρὸς ΚΠ,
καὶ ἡ Δ πρὸς ΠΜ. μὴ γὰρ ἔστω, ἀλλ' ἢ πρὸς
ἐλάττω ἢ πρὸς μείζω τῆς ΠΜ· οὐδὲν γὰρ διοίσει.
ἔστω πρὸς ΠΡ. τὸν αὐτὸν ἄρα λόγον αἱ ΗΚ καὶ
ΚΠ καὶ ἡ ΠΡ πρὸς ἀλλήλας ἕξουσιν ὃνπερ αἱ
Ζ Β Δ.[1] αἱ δὲ Ζ Β Δ[1] ἀνὰ λόγον ἦσαν, ὅνπερ ἡ Δ
πρὸς Β, ἡ ΖΒ πρὸς Δ· ὥστε ὅπερ ἡ ΠΗ πρὸς τὴν
ΠΡ, ἡ τὸ ΠΡ πρὸς τὴν ΠΚ. ἂν οὖν ἀπὸ τῶν
Κ Η αἱ ΗΡ καὶ ΚΡ ἐπὶ τὸ Ρ ἐπιζευχθῶσιν, αἱ
ἐπιζευχθεῖσαι αὗται τὸν αὐτὸν ἕξουσι λόγον ὅνπερ
ἡ ΗΠ πρὸς τὴν ΠΡ· περὶ γὰρ τὴν αὐτὴν γωνίαν
τὴν Π ἀνάλογον αἵ τε τοῦ ΗΠΡ τριγώνου καὶ τοῦ
ΚΡΠ. ὥστε καὶ ἡ ΠΡ πρὸς τὴν ΚΡ τὸν αὐτὸν
ἔξει λόγον, καὶ ἡ τὸ ΗΠ πρὸς τὴν ΠΡ. ἔχει δὲ
καὶ ἡ ΜΗ πρὸς ΚΜ τοῦτον τὸν λόγον· ὅνπερ γὰρ
ἡ τὸ Δ πρὸς τὴν Β ἀμφότεραι. ὥστε ἀπὸ τῶν
Η Κ σημείων οὐ μόνον πρὸς τὴν Μ Ν περιφέρειαν
συσταθήσονται τὸν αὐτὸν ἔχουσαι λόγον, ἀλλὰ καὶ
ἄλλοθι· ὅπερ ἀδύνατον. ἐπεὶ οὖν ἡ Δ οὔτε πρὸς
ἔλαττον τοῦ ΜΠ οὔτε πρὸς μείζω (ὁμοίως γὰρ
δειχθήσεται), δῆλον ὅτι πρὸς αὐτὴν ἂν εἴη τὴν ἐφ'
ᾗ Μ Π. ὥστ' ἔσται ὅπερ ἡ ΜΠ πρὸς ΠΚ, ἡ ΠΗ
πρὸς τὴν ΜΠ [καὶ λοιπὴ ἡ τὸ ΜΗ πρὸς ΜΚ].[2]

Ἐὰν οὖν τῷ ἐφ' ᾧ τὸ Π πόλῳ χρώμενος, διαστήματι δὲ τῷ ἐφ' ᾧ Μ Π, κύκλος γραφῇ, ἁπασῶν
ἐφάψεται τῶν γωνιῶν ἃς ἀνακλώμεναι ποιοῦσιν αἱ
ἀπὸ τοῦ Η καὶ Κ[3]· εἰ δὲ μή, ὁμοίως δειχθήσονται
τὸν αὐτὸν ἔχουσαι λόγον αἱ ἄλλοθι καὶ ἄλλοθι τοῦ
ἡμικυκλίου συνιστάμεναι, ὅπερ ἦν ἀδύνατον. ἐὰν
οὖν περιαγάγῃς τὸ ἡμικύκλιον τὸ ἐφ' ᾧ τὸ Α περὶ
τὴν ἐφ' ᾗ Η Κ Π διάμετρον, αἱ ἀπὸ τοῦ ΗΚ ἀνα-

then be the pole of the circle on which the lines from K fall: for the ratio of Z to KH and B to KΠ is the same as that of Δ to ΠM. For suppose it is not so, and Δ bears this ratio to a line greater or less than ΠM (it does not matter which). Let this line be ΠP. Then HK and KΠ and ΠP will stand in the same ratio to each other as Z, B and Δ. But Z, B and Δ stood in ratios such that Δ was to B as Z + B to Δ: so that ΠH is to ΠP as ΠP to ΠK. If, therefore, from the points K and H the lines HP and KP are drawn to P, the lines so drawn will bear the same ratio to each other as HΠ to ΠP, for the triangles HΠP and KPΠ are homologous about the angle Π. So ΠP will bear the same ratio to KP as HΠ to ΠP. But MH and KM also stand in this ratio, as the ratio of both HΠ to ΠP and MK to MH is the same as that of Δ to B. Therefore, from the points H and K lines standing in the same ratio to each other will have been drawn both to the circumference MN and to another point. Which is impossible. Since, therefore, Δ cannot bear the ratio in question to a line either less or greater than MΠ (the proof in either case is the same), it follows that it must bear that ratio to MΠ itself. So the ratio of MΠ to ΠK is the same as that of ΠH to MΠ [and finally MH to MK].

(4) If, then, a circle is drawn with Π as pole and distance MΠ, it will touch all the angles made by the reflection of the lines from H and K. If not, it can be shown as before that lines drawn to different points on the semicircle A bear the same relation to each other, which is an impossibility. If, then, you revolve the semicircle A about HKΠ as diameter, the

[1] Z B Δ E_1 𝔐 Ap O.T.: Δ B Z Fobes. [2] secl. Fobes.
[3] H *καὶ* K ci. O.T., cf. Ap: MA *κύκλου* Fobes.

376 b
κλώμεναι πρὸς τὸ ἐφ' ᾧ τὸ Μ ἐν πᾶσι τοῖς ἐπιπέδοις ὁμοίως ἕξουσι, καὶ ἴσην ποιήσουσι γωνίαν τὴν ΚΜΗ· καὶ ἣν ποιήσουσι δὲ γωνίαν αἱ ΗΠ καὶ ΜΠ ἐπὶ τῆς ΗΠ, ἀεὶ ἴση ἔσται. τρίγωνα οὖν ἐπὶ τῆς ΗΠ καὶ ΚΠ ἴσα τῷ ΗΜΠ ΚΜΠ συνεστήκασι. τούτων δὲ αἱ κάθετοι ἐπὶ τὸ αὐτὸ σημεῖον πεσοῦνται τῆς ΗΠ καὶ ἴσαι ἔσονται. πιπτέτωσαν ἐπὶ τὸ Ο. κέντρον ἄρα τοῦ κύκλου τὸ Ο, ἡμικύκλιον δὲ τὸ περὶ τὴν ΜΝ[1] ἀφῄρηται ὑπὸ[2] τοῦ ὁρίζοντος.

[Τῶν μὲν γὰρ ἄνω τὸν ἥλιον οὐ κρατεῖν, τῶν δὲ †προσπτεριζομένων† κρατεῖν, καὶ διαχεῖν τὸν ἀέρα· καὶ διὰ τοῦτο τὴν ἶριν οὐ συμβάλλειν τὸν κύκλον. γίγνεσθαι δὲ καὶ νύκτωρ ἀπὸ τῆς σελήνης ὀλιγάκις· οὔτε γὰρ ἀεὶ πλήρης, ἀσθενεστέρα τε τὴν φύσιν ⟨ἢ⟩[3] ὥστε κρατεῖν τοῦ ἀέρος· μάλιστα δ' ἵστασθαι τὴν ἶριν, ὅπου μάλιστα κρατεῖται ὁ ἥλιος· πλείστη γὰρ ἐν αὐτῇ ἰκμὰς ἐνέμεινεν.][4]

Πάλιν ἔστω ὁρίζων μὲν ἐφ' οὗ τὸ ΑΚΓ, ἐπανατεταλκέτω δὲ τὸ Η, ὁ δ' ἄξων ἔστω νῦν ἐφ' οὗ τὸ ΗΠ. τὰ μὲν οὖν ἄλλα πάντα ὁμοίως δειχθήσεται ὡς καὶ πρότερον, ὁ δὲ πόλος τοῦ κύκλου ὁ ἐφ' ᾧ Π κάτω ἔσται τοῦ ὁρίζοντος τοῦ ἐφ' ᾧ τὸ ΑΓ,
377 a ἀρθέντος τοῦ ἐφ' ᾧ τὸ Η σημείου. ἐπὶ δὲ τῆς αὐτῆς ὅ τε πόλος καὶ τὸ κέντρον τοῦ κύκλου καὶ τὸ τοῦ ὁρίζοντος νῦν τὴν ἀνατολήν· ἔστι γὰρ οὗτος

[1] τοῦ περὶ τὴν ΜΝ (sc. κύκλου) ci. O.T.
[2] ὑπὸ $\mathfrak{M}$ $\mathfrak{B}_{rec}$ $F_{corr\ m\ 1}$ H N O.T. : ἀπὸ Fobes.
[3] ἢ ci. O.T.
[4] τῶν μὲν l. 22 . . . ἐνέμεινεν l. 28 damnaverunt O.T. Ideler: om. Ap.

lines reflected from H and K to the point M will bear the same ratio to each other in all planes, and the angle KMH will remain constant, as will also the angle made by HΠ and MΠ upon HΠ. So the triangles on HΠ and KΠ are equal to the triangles HMΠ and KMΠ. Their perpendiculars will fall on the same point in HΠ and all be equal Let the point on which they fall be O Then O is the centre of the circle, of which a semicircle MN is cut off by the horizon.[a]

[For the sun does not master the parts above, but does master those near the earth and dissolve the air. And that is why the circle of the rainbow is not complete. A rainbow at night, due to the moon, is rare For the moon is not always full, and is naturally too feeble to master the air. The rainbow stands most firmly when the sun is most mastered : for then most moisture remains in it][b]

Demonstration (II).

(II) Again, let the horizon be AKΓ, and let H be raised some way above the horizon. And let the axis now be HΠ. The proof will be the same in most respects as the one above, but the pole of the circle Π will be below the horizon AΓ, since the point H has risen above it. The pole, and the centre of the circle (O),[c] and the centre (K) of the circle on whose arc the sun rises (that is, the circle HΠ) are all in

[a] This seems to assume that the great circle A (*cf.* 375 b 33 : MPNH of Fig. 2) is the circle of the horizon, which is not what the earlier parts of the demonstration would lead one to suppose, *cf.* 375 b 30 ff. But Aristotle may be speaking carelessly, or the words may be a gloss (O.T.: there is no trace of them in Alex.). The O.T.'s conjecture, "a semicircle of the circle about MN," would avoid the difficulty.

[b] As Ideler and O.T. remark, this passage is certainly out of place here : and I agree with the O.T. that "it is incoherent in itself and certainly an interpolation "

[c] *i.e.* the circle which is the base of the cone.

377 a
ἐφ' ᾧ τὸ ΗΠ. ἐπεὶ δὲ τῆς διαμέτρου τῆς ΑΓ τὸ
5 ΚΗ ἐπάνω, τὸ κέντρον εἴη ἂν ὑποκάτω τοῦ ὁρί-
ζοντος πρότερον τοῦ ἐφ' ᾧ τὸ ΑΓ, ἐπὶ τῆς ΚΠ
γραμμῆς, ἐφ' οὗ τὸ Ο.[1] ὥστ' ἔλαττον ἔσται τὸ
ἐπάνω τμῆμα ἡμικυκλίου τὸ ἐφ' ᾧ Ψ Υ[a] τὸ γὰρ
ΨΥΩ[2] ἡμικύκλιον ἦν, νῦν δὲ ἀποτέτμηται ὑπὸ[3]
τοῦ ΑΓ ὁρίζοντος. τὸ δὴ ΥΩ[2] ἀφανὲς ἔσται αὐτοῦ,
10 ἐπαρθέντος τοῦ ἡλίου· ἐλάχιστον δ', ὅταν ἐπὶ μεσ-
ημβρίας· ὅσον γὰρ ἀνώτερον τὸ Η, κατώτερον ὅ
τε πόλος καὶ τὸ κέντρον τοῦ κύκλου ἔσται.
Ὅτι δ' ἐν μὲν ταῖς ἐλάττοσιν ἡμέραις ταῖς μετ'
ἰσημερίαν τὴν μετοπωρινὴν ἐνδέχεται ἀεὶ γίγνεσθαι

[1] B Op Fobes: Ο E_{rec} $\mathfrak{B}_{rec}$ $F_{corr\ m\ 1}$ Bekker O.T.
[2] ΨΥΟ, ΟΥ Fobes.
[3] ἀπὸ Fobes: ὑπὸ $\mathfrak{B}_{corr}$ F_{corr} H N O.T.

[a] Though Fobes' readings, ΨΥΟ and ΟΥ, have good authority, it is clear from Fig. 4 that the sense of the passage demands the readings given here, which are those adopted by Bekker and the O.T.

the same straight line But since KH is above the diameter AΓ, the centre will be below the former horizon AΓ on the line KΠ at the point O. The seg-

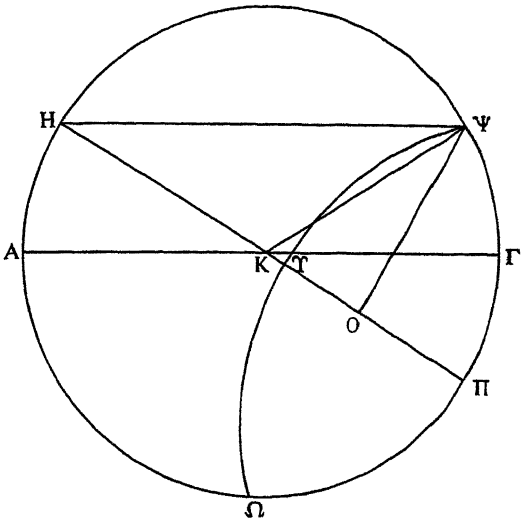


Fig. 4

ment ΨΥ above the horizon will thus be less than a hemisphere : for ΨΥΩ^a is a semicircle and is now cut off by the horizon AΓ. So part of it, ΥΩ,^{a} will be invisible when the sun has risen above the horizon, and the visible segment will be the smallest when the sun is on its meridian. For the higher H is, the lower will be the pole and the centre of the circle

(III) The reason why, during the shorter days after the autumn equinox, it is possible for a rainbow to (III) The effect of the differences

377 a ἶριν, ἐν δὲ ταῖς μακροτέραις ἡμέραις ταῖς ἀπὸ ἰσημερίας τῆς ἑτέρας ἐπὶ τὴν ἰσημερίαν τὴν ἑτέραν περὶ
15 μεσημβρίαν οὐ γίγνεται ἶρις, αἴτιον ὅτι τὰ μὲν πρὸς ἄρκτον τμήματα πάντα μείζω ἡμικυκλίου καὶ ἀεὶ ἐπὶ μείζω ἡμικυκλίου, τὸ δ' ἀφανὲς μικράν, τὰ δὲ πρὸς μεσημβρίαν τμήματα τοῦ ἰσημερινοῦ, τὸ μὲν ἄνω τμῆμα μικρόν, τὸ δ' ὑπὸ γῆν μέγα, καὶ ἀεὶ
20 δὴ μείζω τὰ πορρώτερα· ὥστ' ἐν μὲν ταῖς πρὸς θερινὰς τροπὰς ἡμέραις διὰ τὸ μέγεθος τοῦ τμήματος, πρὶν ἐπὶ τὸ μέσον ἐλθεῖν τοῦ τμήματος καὶ ἐπὶ τὸν μεσημβρινὸν τὴν τὸ Η, κάτω ἤδη τελέως γίγνεται ἡ τὸ Π, διὰ τὸ πόρρω ἀφεστάναι τῆς γῆς τὴν μεσημβρίαν διὰ τὸ μέγεθος τοῦ τμήματος. ἐν
25 δὲ ταῖς πρὸς τὰς χειμερινὰς τροπὰς ἡμέραις, διὰ τὸ μὴ πολὺ ὑπὲρ γῆς εἶναι τὰ τμήματα τῶν κύκλων, τοὐναντίον ἀναγκαῖον γίγνεσθαι βραχὺ γὰρ ἀρθείσης τῆς ἐφ' ᾧ τὸ Η, ἐπὶ τῆς μεσημβρίας γίγνεται ὁ ἥλιος.

CHAPTER VI

ARGUMENT

(1) *Mock suns and rods. Rods are due to the reflection of our sight to the sun from clouds of uneven consistency* (377 a 29–b 15). *Mock suns are due to reflection from even and dense cloud. Mock suns as signs of rain* (377 b 15-27). *Why mock suns and rods appear only at the side of the sun, and not above or beneath it* (377 b 27—378 a 14). (2) *We*

377 a 29 Τὰς δ' αὐτὰς αἰτίας ὑποληπτέον καὶ περὶ παρ-
30 ηλίων καὶ ῥάβδων ταῖς εἰρημέναις.

occur at any time of day, but during the longer days between the spring and autumn equinoxes no rainbow occurs about midday, is as follows: When the sun's orbit is north of the equator the visible segment of it is greater than a semicircle and continues to increase, while the segment that is invisible is small; when it is south of the equator the upper, visible segment is small, while the segment below the earth is large, and increases as the sun recedes. In the days of the summer solstice, therefore, the size of the segment is so large that before the point H reaches the middle of the segment, that is, the meridian, the point Π is already well below the horizon, because the segment is large and therefore the distance of the meridian from the earth great. But in the days of the winter solstice the opposite result must follow, because the segments of the sun's orbit above the earth are not large: for the sun reaches its meridian when the point H has risen only a small distance. In the sun's arc

CHAPTER VI

ARGUMENT (*continued*)

have still to study the effects produced by the two forms of exhalation within the earth. They give rise to two types of substance, minerals and metals (378 a 15–b 6).

With 378 a 15 *ff.* cf. *Eichholz, "Aristotle's Theory of the Formation of Metals and Minerals,"* C.Q. *xliii* (*July-Oct.* 1949).

(1) Mock suns and rods must again be supposed to be produced by the same causes. (1) Mock suns and rods also

377 a Γίγνεται γὰρ παρήλιος μὲν ἀνακλωμένης τῆς ὄψεως πρὸς τὸν ἥλιον, ῥάβδοι δὲ διὰ τὸ προσπίπτειν τοιαύτην οὖσαν τὴν ὄψιν, οἵαν εἴπομεν ἀεὶ γίγνεσθαι ὅταν πλησίον ὄντων τοῦ ἡλίου νεφῶν ἀπό τινος ἀνακλασθῇ τῶν ὑγρῶν πρὸς τὸ νέφος· φαί-
377 b νεται γὰρ αὐτὰ μὲν ἀχρωμάτιστα τὰ νέφη κατ' εὐθυωρίαν εἰσβλέπουσιν, ἐν δὲ τῷ ὕδατι ῥάβδων μεστὸν τὸ νέφος· πλὴν τότε μὲν ἐν τῷ ὕδατι δοκεῖ τὸ χρῶμα τοῦ νέφους εἶναι, ἐν δὲ ταῖς ῥάβδοις ἐπ' αὐτοῦ τοῦ νέφους. γίγνεται δὲ τοῦτο ὅταν ἀνώ-
5 μαλος ἡ τοῦ νέφους ᾖ σύστασις, καὶ τῇ μὲν πυκνότερον τῇ δὲ μανόν, καὶ τῇ μὲν ὑδατωδέστερον τῇ δ' ἧττον· ἀνακλασθείσης γὰρ τῆς ὄψεως πρὸς τὸν ἥλιον, τὸ σχῆμα μὲν [τοῦ ἡλίου][1] οὐχ ὁρᾶται [διὰ μικρότητα τῶν ἐνόπτρων],[1] τὸ δὲ χρῶμα· διὰ δὲ τὸ ἐν ἀνωμάλῳ φαίνεσθαι λαμπρὸν καὶ λευκὸν τὸν
10 ἥλιον, πρὸς ὃν ἀνεκλάσθη ἡ ὄψις, τὸ μὲν φοινικοῦν φαίνεται, τὸ δὲ πράσινον ἢ ξανθόν. διαφέρει γὰρ οὐδὲν διὰ τοιούτων ὁρᾶν ἢ ἀπὸ τοιούτων ἀνακλωμένην· ἀμφοτέρως γὰρ φαίνεται τὴν χρόαν ὅμοιον, ὥστ' εἰ κἀκείνως φοινικοῦν, καὶ οὕτως.

Αἱ μὲν οὖν ῥάβδοι γίγνονται δι' ἀνωμαλίαν τοῦ
15 ἐνόπτρου οὐ τῷ σχήματι ἀλλὰ τῷ χρώματι· ὁ δὲ παρήλιος, ὅταν ὅτι μάλιστα ὁμαλὸς ᾖ ὁ ἀὴρ καὶ πυκνὸς ὁμοίως· διὸ φαίνεται λευκός. ἡ μὲν γὰρ ὁμαλότης τοῦ ἐνόπτρου ποιεῖ χρόαν μίαν τῆς ἐμφάσεως· ἡ δ' ἀνάκλασις ἀθρόας τῆς ὄψεως, διὰ τὸ ἅμα προσπίπτειν πρὸς τὸν ἥλιον ἀπὸ πυκνῆς οὔσης
20 τῆς ἀχλύος, καὶ οὔπω μὲν οὔσης ὕδω̃ρ[2] ἐγγὺς δ'

[1] secl. Fobes.

[2] ὕδωρ Fobes codd.: ὕδατος cl. Thurot qui ὕδωρ non construi posse censet: cf. Ap ὑδατώδους.

A mock sun is caused by the reflection of our sight to the sun. Rods are caused when our sight reaches the sun in the condition in which we have said [a] it does when it is reflected from some liquid surface to a cloud, when there are clouds near the sun · for the clouds when we look directly at them appear colourless, but their reflection in water is full of rods. The only difference is that it is the reflection of the cloud in water that appears coloured, while the colours of the rod appear on the cloud itself This takes place when the consistency of the cloud is uneven, and part of it is dense and part rare, part more and part less, watery. For when the sight is reflected to the sun its shape is not seen owing to the smallness of the reflecting particles,[b] but its colour is · and the clear, bright light of the sun to which our sight is reflected, seen on an uneven reflecting surface, appears partly red, partly green or yellow.[c] It makes no difference whether sight passes through a medium or is reflected from a surface of this kind : in either case a similar colour appears, and if it is red in the one case it will be in the other. due to reflection. Rods.

The colour, therefore, of rods, though not their shape, is caused by the unevenness of the reflecting surface. A mock sun appears when the air is very even and at the same time dense. Hence its bright colour. For the evenness of the reflecting surface produces an image of a single colour ; and our sight is reflected as a whole and projected all at once to the sun from the mist, which is dense and very nearly water though not yet quite, and this reflection causes Mock suns

[a] 374 b 9 ff. *Cf* esp. 374 b 20.
[b] 372 a 32, 373 b 17.
[c] *Cf.* 374 b 30.

377 b ὕδατος, [διὰ][1] τὸ ὑπάρχον τῷ ἡλίῳ ἐμφαίνεσθαι χρῶμα ποιεῖ, ὥσπερ ἀπὸ χαλκοῦ λείου κλωμένην διὰ τὴν πυκνότητα. ὥστ' ἐπεὶ τὸ χρῶμα τοῦ ἡλίου λευκόν, καὶ ὁ παρήλιος φαίνεται λευκός. διὰ δὲ τὸ αὐτὸ τοῦτο μᾶλλον ὕδατος σημεῖον ὁ παρήλιος
25 τῶν ῥάβδων· μᾶλλον γὰρ συμβαίνει τὸν ἀέρα εὐεργῶς ἔχειν πρὸς γένεσιν ὕδατος. ὁ δὲ νότιος τοῦ βορείου μᾶλλον, ὅτι μᾶλλον ὁ νότιος ἀὴρ εἰς ὕδωρ μεταβάλλει τοῦ πρὸς ἄρκτον.

Γίγνονται δ', ὥσπερ εἴπομεν, περί τε δυσμὰς καὶ περὶ τὰς ἀνατολάς, καὶ οὔτε ἄνωθεν οὔτε κάτω-
30 θεν, ἀλλ' ἐκ τῶν πλαγίων καὶ ῥάβδοι καὶ παρήλιοι· καὶ οὔτ' ἐγγὺς τοῦ ἡλίου λίαν οὔτε πόρρω παντελῶς· ἐγγὺς μὲν γὰρ οὖσαν ὁ ἥλιος διαλύει τὴν σύστασιν, πόρρω δ' οὔσης ἡ ὄψις οὐκ ἀνακλασθήσεται· ἀπὸ γὰρ μικροῦ ἐνόπτρου πόρρω ἀποτεινομένη ἀσθενὴς γίγνεται· διὸ καὶ αἱ ἅλως οὐ γίγνονται ἐξ ἐναντίας
378 a τοῦ ἡλίου. ἄνω μὲν οὖν ἐὰν γίγνηται καὶ ἐγγύς, διαλύσει ὁ ἥλιος· ἐὰν δὲ πόρρω, ἐλάττων ἡ ὄψις οὖσα ἢ ὥστε ποιεῖν ἀνάκλασιν οὐ προσπεσεῖται. ἐν δὲ τῷ πλαγίῳ [ὑπὸ τὸν ἥλιον][2] ἐστὶ τοσοῦτον ἀποστῆναι τὸ ἔνοπτρον, ὥστε μήτε τὸν ἥλιον δια-
5 λῦσαι, τήν τε ὄψιν ἀθρόαν ἐλθεῖν, διὰ τὸ πρὸς τῇ γῇ[3] φερομένην μὴ διασπᾶσθαι ὥσπερ δι' ἀχανοῦς φερομένην. ὑπὸ δὲ τὸν ἥλιον οὐ γίγνεται διὰ τὸ πλησίον μὲν τῆς γῆς διαλύεσθαι ἂν ὑπὸ τοῦ ἡλίου, ἄνω δὲ μεσουρανίου ⟨γιγνομένης συστάσεως⟩[4] τὴν ὄψιν διασπᾶσθαι. καὶ ὅλως οὐδ' ἐκ πλαγίου μεσ-

[1] secl. Fobes. [2] secl. Fobes.
[3] τῇ γῇ O.T τὴν γῆν Fobes.

the sun's real colour to appear, as it does when our sight is reflected by the density of a polished copper surface As the colour of the sun is bright, so, therefore, is the colour of the mock sun. For this same reason the mock sun is more a sign of rain than of rods, the air being in a more favourable condition for the production of water And a mock sun in the south is more of a sign of rain than one in the north, because the air in the south is more liable to change to water than the air towards the north.

Both rods and mock suns occur, as we said,[a] at sunset and sunrise, and neither above nor below the sun, but beside it. Nor do they occur very close to the sun, nor very far off. For if the condensation is close the sun dissolves it, and if it is far off the sight is not reflected. For when the reflecting surface is small the sight grows progressively weaker as the distance increases, which is why haloes do not occur opposite the sun If, then, the condensation is close to the sun and above it, the sun will dissolve it · if it is far at a distance from it, the sight is too weak to produce a reflection and does not reach it. But at the side of the sun the reflecting material can be far enough away for the sun not to dissolve it, yet near enough for sight to reach it as a whole, because its course is near the earth and it is not, as it were, dissipated on its journey through space. Reflection does not take place below the sun because close to the earth the sun would dissolve the reflecting material, whereas when it forms high in the heavens the sight is dissipated. Indeed it does not take place even at the

[a] 372 a 10.

[4] *γιγνομένης συστάσεως* cl. Fobes, cf. Ap: *ὄντος* E 𝔚.

378 a

ουρανίου γίγνεται· ἡ γὰρ ὄψις οὐ πρὸς τῇ γῇ[1] φέρεται, ὥστε ὀλίγη ἀφικνεῖται πρὸς τὸ ἔνοπτρον, καὶ ἡ ἀνακλωμένη γίγνεται πάμπαν ἀσθενής.

Ὅσα μὲν οὖν ἔργα συμβαίνει παρέχεσθαι τὴν ἔκκρισιν ἐν τοῖς τόποις τοῖς ὑπὲρ τῆς γῆς, σχεδόν ἐστι τοσαῦτα καὶ τοιαῦτα. ὅσα δ' ἐν αὐτῇ τῇ γῇ, ἐγκατακλειομένη τοῖς τῆς γῆς μέρεσιν, ἀπεργάζεται, λεκτέον.

Ποιεῖ γὰρ δύο διαφορὰς σωμάτων διὰ τὸ διπλῆ πεφυκέναι καὶ αὐτή, καθάπερ καὶ ἐν τῷ μετεώρῳ· δύο μὲν γὰρ αἱ ἀναθυμιάσεις, ἡ μὲν ἀτμιδώδης ἡ δὲ καπνώδης, ὥς φαμεν, εἰσίν δύο δὲ καὶ τὰ εἴδη τῶν ἐν τῇ γῇ γιγνομένων, τὰ μὲν ὀρυκτὰ τὰ δὲ μεταλλευτά. ἡ μὲν οὖν ξηρὰ ἀναθυμίασίς ἐστιν ἥ τις ἐκπυροῦσα ποιεῖ τὰ ὀρυκτὰ πάντα, οἷον λίθων τε γένη τὰ ἄπηκτα καὶ σανδαράκην καὶ ὤχραν καὶ μίλτον καὶ θεῖον καὶ τἆλλα τὰ τοιαῦτα. τὰ δὲ πλεῖστα τῶν ὀρυκτῶν ἐστιν τὰ μὲν κονία κεχρωματισμένη, τὰ δὲ λίθος ἐκ τοιαύτης γεγονὼς συστάσεως, οἷον τὸ κιννάβαρι. τῆς δ' ἀναθυμιάσεως τῆς ἀτμιδώδους, ὅσα μεταλλεύεται, καὶ ἔστιν ἢ χυτὰ ἢ ἐλατά, οἷον σίδηρος, χρυσός, χαλκός. ποιεῖ δὲ ταῦτα πάντα ἡ ἀναθυμίασις ἡ ἀτμιδώδης ἐγκατακλειομένη, καὶ μάλιστα ἐν τοῖς λίθοις, διὰ ξηρότητα εἰς ἓν συνθλιβομένη καὶ πηγνυμένη, οἷον ἢ δρόσος ἢ πάχνη, ὅταν ἀποκριθῇ. ἐνταῦθα δὲ πρὶν ἀποκριθῆναι γεννᾶται ταῦτα. διὸ ἔστι μὲν ὡς ὕδωρ ταῦτα, ἔστιν δ' ὡς οὔ· δυνάμει μὲν γὰρ ἡ ὕλη ὕδατος ἦν, ἔστι δ' οὐκέτι, οὐδ' ἐξ ὕδατος γενομένου διά τι

[1] πρὸς τῇ γῇ Ap : ὑπὸ τὴν γῆν Fobes codd.

[a] Lit. substances dug or quarried and substances mined. "The 'fossiles' include not only certain minerals such as

side of the sun when it is high : for our sight is not then travelling close to the earth, and so when it reaches the reflecting surface it is already weak and its reflection lacks force entirely.

(2) This, then, completes our enumeration of the kind of effects produced by exhalation in the regions above the earth's surface . we have still to describe those which it produces when enclosed in the parts of the earth (2) The two forms of exhalation within the earth

It produces two different kinds of body, being itself twofold just as it is in the upper regions For there are, we maintain, two exhalations, one vaporous and one smoky ; and there are two corresponding kinds of body produced within the earth, " fossiles " and metals.[a] The dry exhalation by the action of its heat produces all the " fossiles," for example, all kinds of stones that are infusible—realgar, ochre, ruddle, sulphur and all other substances of this kind. Most " fossiles " are coloured dust or stone formed of a similar composition, for instance cinnabar. Metals are the product of the vaporous exhalation, and are all fusible or ductile, for example, iron, gold, copper. These are all produced by the enclosure of the vaporous exhalation, particularly within stones, whose dryness compresses it together and solidifies it, just as dew and frost [b] solidify when they have been separated—only metals are produced before separation has taken place. So they are in a sense water and in another sense not : it was possible for their material to turn into water, but it can no longer do so, nor are they, like tastes, the result of some change of

realgar, ochre, ruddle, sulphur and cinnabar, but also those stones which cannot be melted " (Eichholz, *loc. cit*).

[b] Book I. ch. 10.

378 b πάθος, ὥσπερ οἱ χυμοί· οὐδὲ γὰρ οὕτω γίγνεται τὸ μὲν χαλκὸς τὸ δὲ χρυσός, ἀλλὰ πρὶν γενέσθαι παγείσης τῆς ἀναθυμιάσεως ἕκαστα τούτων ἐστίν. διὸ καὶ πυροῦται πάντα καὶ γῆν ἔχει· ξηρὰν γὰρ ἔχει ἀναθυμίασιν· ὁ δὲ χρυσὸς μόνος οὐ πυροῦται.

5 Κοινῇ μὲν οὖν εἴρηται περὶ αὐτῶν ἁπάντων, ἰδίᾳ δὲ σκεπτέον προχειριζομένοις περὶ ἕκαστον γένος.

quality in water that has already formed. For this is not the way in which copper or gold is produced, but each is the result of the solidification of the exhalation before it turns to water. So all metals are affected by fire and contain earth, for they contain dry exhalation The only exception is gold, which is not affected by fire.

So much for a general account of these bodies; we must now take each kind separately and examine it in detail.

Δ

CHAPTER I

ARGUMENT

Of the four constituent qualities of the four elements, two, heat and cold, are active, two, moist and dry, are passive (378 b 10-26). *These factors, active and passive, give rise to generation, change and destruction* (378 b 26—379 a 11). *Destruction is due to the failure of the active factors in a thing to master the passive. Decay is due to the destruction of a moist body's natural heat by external heat, and so may be said to be due to internal cold or external heat. Confirmatory examples* (379 a 11–b 9).

378 b 10 Ἐπεὶ δὲ τέτταρα αἴτια διώρισται τῶν στοιχείων, τούτων δὲ κατὰ συζυγίας καὶ τὰ στοιχεῖα τέτταρα συμβέβηκεν εἶναι, ὧν τὰ μὲν δύο ποιητικά, τὸ θερμὸν καὶ τὸ ψυχρόν, τὰ δὲ δύο παθητικά, τὸ ξηρὸν καὶ τὸ ὑγρόν· ἡ δὲ πίστις τούτων ἐκ τῆς ἐπαγωγῆς· 15 φαίνεται γὰρ ἐν πᾶσιν ἡ μὲν θερμότης καὶ ψυχρότης ὁρίζουσαι καὶ συμφύουσαι καὶ μεταβάλλουσαι τά θ' ὁμογενῆ καὶ τὰ μὴ ὁμογενῆ, καὶ ὑγραίνουσαι καὶ ξηραίνουσαι καὶ σκληρύνουσαι καὶ μαλάττουσαι, τὰ δὲ ξηρὰ καὶ ὑγρὰ ὁριζόμενα καὶ τἆλλα τὰ εἰρη-

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[a] *Cf.* Book I. ch. 2. For the general doctrine of the four elements, each of which is composed of prime matter and a

BOOK IV

CHAPTER I

ARGUMENT (*continued*)

Note.—*The word translated "generation" in this chapter* (γένεσις) *covers all processes of coming into existence of whatever kind; "destruction"* (φθορά), *correspondingly, covers all kinds of passing out of existence; "decay"* (σῆψις) *is a particular, but very common, type of "destruction"* (φθορά), *covering generally cases in which a thing decays, disintegrates or perishes in the ordinary course of nature* (cf. 379 a 3), *its literal meaning being "putrefaction."*

The active and passive qualities,

We have distinguished in the elements four causal factors whose combinations yield four elements[a]: two of the factors are active, the hot and the cold, two are passive, the moist and the dry. This can be confirmed by considering some examples. (1) It is always heat and cold that are observed to determine, combine and change things both of the same and of different kinds, as well as moistening, drying, hardening and softening: things dry and moist, on the other hand, are the subjects of determination and the other changes just

pair of the prime contrarieties (fire = hot-dry, air = moist-hot, water = moist-cold, earth = dry-cold), see *De Caelo* III-IV, *De Gen. et Corr.* II 1-6. For the view that hot and cold are active, moist and dry passive, *cf.* in particular *De Gen. et Corr.* II. 2, 329 b 20-33, and Joachim's note *ad* 329 b 24-26.

378 b μένα πάθη πάσχοντα αὐτά τε καθ' αὑτὰ καὶ ὅσα
κοινὰ ἐξ ἀμφοῖν σώματα συνέστηκεν· ἔτι δ' ἐκ τῶν
λόγων δῆλον, οἷς ὁριζόμεθα τὰς φύσεις αὐτῶν· τὸ
μὲν γὰρ θερμὸν καὶ ψυχρὸν ὡς ποιητικὰ λέγομεν
(τὸ γὰρ συγκριτικὸν ὥσπερ ποιητικόν τί ἐστι), τὸ
δὲ ὑγρὸν καὶ ξηρὸν παθητικόν (τὸ γὰρ εὐόριστον
καὶ δυσόριστον τῷ πάσχειν τι λέγεται τὴν φύσιν
αὐτῶν).

Ὅτι μὲν οὖν τὰ μὲν ποιητικὰ τὰ δὲ παθητικά, φα-
νερόν. διωρισμένων δὲ τούτων ληπτέον ἂν εἴη τὰς
ἐργασίας αὐτῶν, αἷς ἐργάζονται τὰ ποιητικά, καὶ
τῶν παθητικῶν τὰ εἴδη. πρῶτον μὲν οὖν καθόλου
ἡ ἁπλῆ γένεσις καὶ ἡ φυσικὴ μεταβολὴ τούτων τῶν
δυνάμεών ἐστιν ἔργον, καὶ ἡ ἀντικειμένη φθορὰ
κατὰ φύσιν. αὗται μὲν οὖν τοῖς τε φυτοῖς ὑπάρ-
χουσι καὶ ζῴοις καὶ τοῖς μέρεσιν αὐτῶν. ἔστι δ'
ἡ ἁπλῆ καὶ ἡ φυσικὴ γένεσις μεταβολὴ ὑπὸ τούτων
τῶν δυνάμεων, ὅταν ἔχωσι λόγον, ἐκ τῆς ὑποκει-
379 a μένης ὕλης ἑκάστῃ φύσει· αὗται δ' εἰσὶν αἱ εἰρη-
μέναι δυνάμεις παθητικαί. γεννῶσι δὲ τὸ θερμὸν
καὶ ψυχρὸν κρατοῦντα τῆς ὕλης· ὅταν δὲ μὴ κρατῇ,
κατὰ μέρος μὲν μόλυνσις καὶ ἀπεψία γίγνεται. τῇ
δ' ἁπλῇ γενέσει ἐναντίον μάλιστα κοινὸν σῆψις·
πᾶσα γὰρ ἡ κατὰ φύσιν φθορὰ εἰς τοῦθ' ὁδός ἐστιν,
5 οἷον γῆρας καὶ αὔανσις. τέλος δὲ πάντων [τῶν
ἄλλων τούτων][1] σαπρότης, ἐὰν μή τι βίᾳ φθαρῇ,[2]
τῶν φύσει συνεστώτων· ἔστιν γὰρ καὶ σάρκα καὶ
ὀστοῦν καὶ ὁτιοῦν κατακαῦσαι, ὧν τὸ τέλος τῆς

[1] seclusi. *τούτων ἁπάντων* O.T. *γὰρ τῶν ἄλλων ἁπάντων* E_1 : *γὰρ τούτων ἁπάντων* E_{corr} $\mathfrak{W}$: *enim horum cunctorum* Henricus : *δὲ τῶν ἄλλων ἁπάντων* Bekker.

[2] post *φθαρῇ* virgulam ponunt Thurot O.T.

enumerated, both in isolation and in combination with each other. (2) We can see the same thing by examining the terms of the definitions we give of the natures of these factors. For we speak of the hot and the cold as active (for what causes combination is in a sense active) and the moist and the dry as passive (for what is unresistant or resistant is so described in virtue of being affected in a certain way).

It is clear, therefore, that of the four factors two are active, two passive. Having established this, we must describe the operations of the active factors and the forms taken by the passive. First, then, simple generation and natural change are the result of these properties, as well as the corresponding natural destruction: and these processes occur both in plants and in animals and their constituent parts. Simple, natural generation is a change effected by these properties, when present in the right proportions, in the matter underlying a particular natural thing, this matter being the passive properties of which we have spoken. The hot and the cold produce change by mastering the matter: when they fail to master it the result is half-cooked[a] and undigested. But the most general contrary to simple generation is decay. For all natural destruction leads to decay, for instance old age and withering, and all compound natural bodies rot in the end,[b] unless they are destroyed by violence: for it is of course quite possible to destroy by burning either flesh, bone or anything else which in the ordinary course of nature is finally destroyed by

their mutual relations cause generation, change and destruction.

[a] *Cf* 381 a 12 and ch 3, note *b* on p. 306.

[b] The omission of *τῶν ἄλλων τούτων* gives the sense that seems to be required, though there is no MS. justification for the omission; the passage is clearly corrupt and the words may be a gloss on *πάντων*.

379 a κατὰ φύσιν φθορᾶς σῆψίς ἐστιν. διὸ ὑγρὰ πρῶτον, εἶτα ξηρὰ τέλος γίγνεται τὰ σηπόμενα· ἐκ τούτων γὰρ ἐγένετο, καὶ ὡρίσθη τῷ ὑγρῷ τὸ ξηρὸν ἐργαζομένων τῶν ποιητικῶν.

Γίγνεται δ' ἡ φθορὰ ὅταν κρατῇ τοῦ ὁρίζοντος τὸ ὁριζόμενον διὰ τὸ περιέχον. (οὐ μὴν ἀλλ' ἰδίως γε λέγεται σῆψις ἐπὶ τῶν κατὰ μέρος φθειρομένων, ὅταν χωρισθῇ τῆς φύσεως.) διὸ καὶ σήπεται πάντα τἆλλα πλὴν πυρός· καὶ γὰρ γῆ καὶ ὕδωρ καὶ ἀὴρ σήπεται· πάντα γὰρ ὕλη τῷ πυρί ἐστι ταῦτα. σῆψις δ' ἐστὶν φθορὰ τῆς ἐν ἑκάστῳ ὑγρῷ οἰκείας καὶ κατὰ φύσιν θερμότητος ὑπ' ἀλλοτρίας θερμότητος· αὕτη δ' ἐστὶν ἡ τοῦ περιέχοντος. ὥστε ἐπεὶ κατ' ἔνδειαν πάσχει θερμοῦ, ἐνδεὲς δὲ ὂν τοιαύτης δυνάμεως ψυχρὸν πᾶν, ἄμφω ἂν αἴτια εἴη, καὶ κοινὸν τὸ πάθος ἡ σῆψις, ψυχρότητός τε οἰκείας καὶ θερμότητος ἀλλοτρίας διὰ τοῦτο γὰρ καὶ ξηρότερα γίγνεται τὰ σηπόμενα πάντα, καὶ τέλος γῆ καὶ κόπρος· ἐξιόντος γὰρ τοῦ οἰκείου θερμοῦ συνεξατμίζεται τὸ κατὰ φύσιν ὑγρόν, καὶ τὸ σπῶν τὴν ὑγρότητα οὐκ ἔστιν· ἐπάγει γὰρ ἕλκουσα ἡ οἰκεία θερμότης. καὶ ἐν τοῖς ψύχεσι δ' ἧττον σήπεται ἢ ἐν ταῖς ἁλέαις (ἐν μὲν γὰρ τῷ χειμῶνι ὀλίγον ἐν τῷ περιέχοντι ἀέρι καὶ ὕδατι τὸ θερμόν, ὥστ' οὐδὲν ἰσχύει, ἐν δὲ τῷ θέρει πλέον)· καὶ οὔτε τὸ πεπηγός (μᾶλλον γὰρ ψυχρὸν ἢ ὁ ἀὴρ θερμόν· οὔκουν κρατεῖται, τὸ δὲ κινοῦν κρατεῖ) οὔτε

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[a] *Cf.* Joachim, *loc. cit* : for the importance of *σύμφυτον θερμόν cf.* Jaeger, *Hermes* xlviii. pp. 43-55, and Joachim, *Journal of Philology*, xxix (1903), pp. 72-86, and *De Part. An.*

decay. Things, therefore, that are decaying become first moist and then in the end dry: for it was from these properties that they originated, the moist being determined by the dry through the operation of the active properties

Destruction takes place when what is being determined gets the better of what is determining it with the help of its environment (though there is a special sense in which decay is used of things which are partially destroyed, when they have departed from their true nature) So everything else decays except fire · for earth, water and air all decay, since all are matter in relation to fire. Decay is the destruction of a moist body's own natural heat by heat external to it, that is, the heat of its environment.[a] Since, therefore, a thing is so affected because of lack of heat, and as everything that lacks this property is cold, decay is caused by and is the common result alike of internal coldness and external heat. That is why everything that decays gets drier, until it ends as earth or dung: for as its own heat leaves it its natural moisture evaporates, and there is nothing to suck moisture into it (this being the function of its own heat, which attracts and draws moisture in). And there is less decay in cold than in warm weather: for in winter the amount of heat in the surrounding air and water is so small as to be ineffective, while in summer it is greater. Again, what is frozen does not decay, as its cold is greater than the air's heat, and therefore is not mastered by it but what causes change in a thing does master it. Nor does any-

Destruction and decay, how caused.

ii. 3, 650 a 2 ff., *De Gen. An.* 736 b 33 ff., 742 a 14, 784 a 34 ff., *De Vit. et Mort* 469 b 7-20, with Book II. ch. 2, 355 b 9 above.

379 a τὸ ζέον ἢ θερμόν (ἐλάττων γὰρ ἡ ἐν τῷ ἀέρι θερμότης τῆς ἐν τῷ πράγματι, ὥστ' οὐ κρατεῖ οὐδὲ ποιεῖ μεταβολὴν οὐδεμίαν). ὁμοίως δὲ καὶ τὸ κινούμενον καὶ ῥέον ἧττον σήπεται τοῦ ἀκινητίζοντος· ἀσθενε-
35 στέρα γὰρ γίγνεται ἡ ὑπὸ τῆς ἐν τῷ ἀέρι θερμό-
379 b τητος κίνησις τῆς ἐν τῷ πράγματι προϋπαρχούσης, ὥστε οὐδὲν ποιεῖ μεταβάλλειν. ἡ δ' αὐτὴ αἰτία καὶ τοῦ τὸ πολὺ ἧττον τοῦ ὀλίγου σήπεσθαι· ἐν γὰρ τῷ πλέονι πλέον ἐστὶν πῦρ οἰκεῖον καὶ ψυχρὸν ἢ ὥστε κρατεῖν τὰς ἐν τῷ περιεστῶτι δυνάμεις. διὸ
5 ἡ θάλαττα κατὰ μέρος μὲν διαιρουμένη ταχὺ σήπεται, ἅπασα δ' οὔ, καὶ τἆλλα ὕδατα ὡσαύτως. καὶ ζῷα ἐγγίγνεται τοῖς σηπομένοις διὰ τὸ τὴν ἀποκεκριμένην θερμότητα φυσικὴν οὖσαν συνιστάναι τὰ ἐκκριθέντα

Τί μὲν οὖν ἐστι γένεσις καὶ τί φθορά, εἴρηται.

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[a] *Cf.* 389 b 5: Aristotle believed that living things (*e.g.* maggots) are produced spontaneously from decaying

CHAPTER II

ARGUMENT

Chapter I has dealt with heat and cold as causes of growth and decay in general, the processes which produce or destroy natural bodies: Chapter II goes on to deal with their effects on bodies so produced. The effect of heat on bodies is con-

379 b 10 Λοιπὸν δ' εἰπεῖν τὰ ἐχόμενα εἴδη, ὅσα αἱ εἰρημέναι δυνάμεις ἐργάζονται ἐξ ὑποκειμένων τῶν φύσει συνεστώτων ἤδη.

thing boiling or hot decay, because the heat in the surrounding air is less than that in the object, and so does not master it or cause any change. Similarly, what is in motion or flowing decays less easily than what is static. For the motive force of the heat in the air is less than that of the heat residing in the object, and so causes no change. For the same reason large quantities decay less than small ones for the larger quantity has too much native heat and cold in it for the properties of its environment to master. Therefore sea water in small quantities decays rapidly, but in bulk it does not and the same is true of other kinds of water. Living things are generated in decaying matter because the natural heat which is expelled compounds them out of the material thrown off with it [a]

This completes our description of generation and destruction.

matter · *cf. Hist. An.* v. 2 and Bonitz, *Index*, 124 b 3-22, for further references.

CHAPTER II

ARGUMENT (*continued*)

coction, of which there are three species, ripening, boiling and roasting : the effect of cold is inconcoction, whose species are rawness, scalding and scorching (379 b 10-18). *Concoction and inconcoction. Concoction is maturity, produced by heat . inconcoction its opposite* (379 b 18—380 a 10).

We must next describe the kind of effect which the properties in question produce when operating on already constituted natural bodies as their material.

379 b

Ἔστι δὴ θερμοῦ μὲν πέψις, πέψεως δὲ πέπανσις, ἕψησις, ἔτι ὄπτησις· ψυχρότητος δὲ ἀπεψία, ταύτης δὲ ὠμότης, μόλυνσις, στάτευσις. δεῖ δὲ ὑπολαμ-
15 βάνειν μὴ κυρίως ταῦτα λέγεσθαι τὰ ὀνόματα τοῖς πράγμασιν, ἀλλ' οὐ κεῖται καθόλου τοῖς ὁμοίοις, ὥστε οὐ ταῦτα ἀλλὰ τοιαῦτα δεῖ νομίζειν εἶναι τὰ εἰρημένα εἴδη.

Εἴπωμεν δ' αὐτῶν ἕκαστον τί ἐστιν.

Πέψις μὲν οὖν ἐστιν τελείωσις ὑπὸ τοῦ φυσικοῦ καὶ οἰκείου θερμοῦ ἐκ τῶν ἀντικειμένων παθη-
20 τικῶν· ταῦτα δ' ἐστὶν ἡ οἰκεία ἑκάστῳ ὕλη. ὅταν γὰρ πεφθῇ, τετελείωταί τε καὶ γέγονεν. καὶ ἡ ἀρχὴ τῆς τελειώσεως ὑπὸ θερμότητος τῆς οἰκείας συμβαίνει, κἂν διά τινος τῶν ἐκτὸς βοηθείας συνεπιτελεσθῇ, οἷον ἡ τροφὴ συμπέττεται καὶ διὰ λουτρῶν καὶ δι' ἄλλων τοιούτων· ἀλλ' ἥ γε ἀρχὴ ἡ ἐν
25 αὐτῷ θερμότης ἐστίν. τὸ δὲ τέλος τοῖς μὲν ἡ φύσις ἐστίν, φύσις δὲ ἣν λέγομεν ὡς εἶδος καὶ οὐσίαν· τοῖς δὲ εἰς ὑποκειμένην τινὰ μορφὴν τὸ τέλος ἐστὶ τῆς πέψεως, ὅταν τοιονδὶ γένηται καὶ τοσονδὶ τὸ ὑγρὸν ἢ ὀπτώμενον ἢ ἑψόμενον ἢ σηπόμενον[1] ἢ ἄλλως πως θερμαινόμενον· τότε γὰρ
30 χρήσιμόν ἐστι καὶ πεπέφθαι φαμέν, ὥσπερ τὸ γλεῦκος καὶ τὰ ἐν τοῖς φύμασιν συνιστάμενα, ὅταν γένηται πύον, καὶ τὸ δάκρυον, ὅταν γένηται λήμη· ὁμοίως δὲ καὶ τἆλλα.

[1] *πεπαινόμενον* (in O glossam) ci. Thurot.

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[a] Notice that Aristotle assimilates chemical change of all

The effect of heat is concoction, and there are three species of concoction, ripening, boiling and roasting. the effect of cold is inconcoction, whose species are rawness, scalding and scorching. It must, however, be understood that these terms do not properly describe the subject-matter under discussion, nor cover all the phenomena which should be classed together as similar. the terms just mentioned must therefore be interpreted to cover all phenomena which should be classed with them and not only those covered by their normal meaning.[a] Concoction, inconcoction and their species.

Let us deal with them in order.

Concoction is maturity, produced from the opposite, passive characteristics by a thing's own natural heat, these passive characteristics being the matter proper to the particular thing. For when a thing has been concocted it has become fully mature And the maturing process is initiated by the thing's own heat, even though external aids may contribute to it. as, for instance, baths and the like may aid digestion, but it is initiated by the body's own heat. In some cases the end of the process is a thing's nature, in the sense of its form and essence. In others the end of concoction is the realization of some latent form, as when moisture takes on a certain quality and quantity when cooked or boiled or rotted[b] or otherwise heated; for then it is useful for something and we say it has been concocted. Examples are must, the pus that gathers in boils, and tears when they become rheum; and so on. Concoction.

kinds (for this is, in our terms, what he is trying to explain) to the two easily observable processes of cooking food and ripening fruit: *cf.* 380 a 16, 381 a 10, b 3 below.

[b] The sense given by Thurot's alternative reading, "ripened," is better.

379 b

Συμβαίνει δὲ τοῦτο πάσχειν ἅπασιν, ὅταν κρατηθῇ ἡ ὕλη καὶ ἡ ὑγρότης· αὕτη γάρ ἐστιν ἡ ὁριζομένη ὑπὸ τῆς ἐν τῇ φύσει θερμότητος. ἕως γὰρ 380 a ἂν ἐνῇ ἐν αὐτῇ ὁ λόγος, φύσις τοῦτ' ἐστίν. διὸ καὶ ὑγιείας σημεῖα τὰ τοιαῦτα, καὶ οὖρα καὶ ὑποχωρήσεις καὶ ὅλως τὰ περιττώματα. καὶ λέγεται πεπέφθαι, ὅτι δηλοῖ κρατεῖν τὴν θερμότητα τὴν οἰκείαν τοῦ ἀορίστου. ἀνάγκη δὲ τὰ πεττόμενα παχύτερα καὶ θερμότερα εἶναι· τοιοῦτον γὰρ ἀποτελεῖ τὸ θερμόν, εὐογκότερον καὶ παχύτερον καὶ ξηρότερον.

Πέψις μὲν οὖν τοῦτο ἐστίν· ἀπεψία δὲ ἀτέλεια δι' ἔνδειαν τῆς οἰκείας θερμότητος (ἡ δὲ ἔνδεια τῆς θερμότητος ψυχρότης ἐστίν)· ἡ δ' ἀτέλειά ἐστιν τῶν ἀντικειμένων παθητικῶν, ἥπερ ἐστὶν ἑκάστῳ φύσει ὕλη.

Πέψις μὲν οὖν καὶ ἀπεψία διωρίσθω τοῦτον τὸν τρόπον.

CHAPTER III

ARGUMENT

The species of concoction and inconcoction. Ripening (380 a 11-27), *rawness* (380 a 27–b 11), *boiling* (380 b 12—

380 a 11 Πέπανσις δ' ἐστὶν πέψις τις· ἡ γὰρ τῆς ἐν τοῖς περικαρπίοις τροφῆς πέψις πέπανσις λέγεται. ἐπεὶ δ' ἡ πέψις τελέωσις, τότε ἡ πέπανσις τελέα ἐστὶν ὅταν τὰ ἐν τῷ περικαρπίῳ σπέρματα δύνηται ἀποτελεῖν τοιοῦτον ἕτερον οἷον αὐτό· καὶ γὰρ ἐπὶ τῶν ἄλλων τὸ τέλεον οὕτω λέγομεν. περικαρπίου μὲν

Concoction, in fact, is what happens to everything when its constituent moisture is mastered; for this is the material that is determined by a thing's natural heat, and as long as the determining proportion holds a thing's nature is maintained. So urine and excreta and the waste products of the body in general are a sign of health, and we say they have been concocted because they show that its own inherent heat has mastered the indeterminate matter. Things concocted are necessarily denser and hotter, for the effect of heat is to make things compacter, denser and drier.

So much for concoction. Inconcoction is a failure to reach maturity owing to a deficiency in natural heat, and lack of heat is of course cold. This immaturity is one of the opposite passive qualities which are the natural matter of all things. Inconcoction.

This completes our description of concoction and inconcoction.

CHAPTER III

ARGUMENT (*continued*)

381 a 12), *scalding* (381 a 12-23), *roasting* (381 a 23–b 13) *and its opposite* (381 b 13-20).

RIPENING is a sort of concoction. For the concoction of the nourishing element in fruit is called ripening, and since concoction is maturity, the process of ripening is complete when the seeds in the fruit are capable of producing another fruit of the same kind: for this is what we mean by mature in other cases also. This, Ripening.

380 a οὖν αὕτη πέπανσις, λέγεται δὲ καὶ ἄλλα πολλὰ πέπονα τῶν πεπεμμένων, κατὰ μὲν τὴν αὐτὴν ἰδέαν, μεταφοραῖς δέ, διὰ τὸ μὴ κεῖσθαι, καθάπερ εἴρηται καὶ πρότερον, ὀνόματα καθ' ἑκάστην τε-
20 λείωσιν περὶ τὰ ὁριζόμενα ὑπὸ τῆς φυσικῆς θερμότητος καὶ ψυχρότητος. ἔστιν δὲ ἡ φυμάτων καὶ φλέγματος καὶ τῶν τοιούτων πέπανσις ἡ ὑπὸ τοῦ φυσικοῦ θερμοῦ τοῦ ἐνόντος ὑγροῦ πέψις· ἀδύνατον γὰρ ὁρίζειν μὴ κρατοῦν. ἐκ μὲν οὖν τῶν πνευματικῶν ὑδατώδη, ἐκ δὲ τῶν τοιούτων τὰ γεηρὰ
25 συνίσταται, καὶ ἐκ λεπτῶν αἰεὶ παχύτερα γίγνεται πεπαινόμενα πάντα. καὶ τὰ μὲν εἰς αὐτὴν[1] ἡ φύσις ἄγει κατὰ τοῦτο, τὰ δὲ ἐκβάλλει.

Πέπανσις μὲν οὖν εἴρηται τί ἐστιν. ὠμότης δ' ἐστὶν τὸ ἐναντίον· ἐναντίον δὲ πεπάνσει ἀπεψία τῆς ἐν τῷ περικαρπίῳ τροφῆς· αὕτη δ' ἐστὶν
30 ἡ ἀόριστος ὑγρότης. διὸ ἢ πνευματικὴ ἢ ὑδατώδης ἢ τῶν ἐξ ἀμφοῖν ἐστιν ἡ ὠμότης. ἐπεὶ δ' ἡ πέπανσις τελέωσίς τίς ἐστιν ἡ ὠμότης ἀτέλεια ἔσται. γίγνεται δ' ἡ ἀτέλεια δι' ἔνδειαν τοῦ φυσικοῦ θερμοῦ καὶ ἀσυμμετρίαν πρὸς τὸ ὑγρὸν τὸ πεπαινόμενον. οὐδὲν δὲ ὑγρὸν αὐτὸ καθ' αὑτὸ πεπαίνεται ἄνευ ξηροῦ· ὕδωρ γὰρ οὐ παχύνεται
380 b μόνον τῶν ὑγρῶν. συμβαίνει δὲ τοῦτο ἢ τῷ τὸ θερμὸν ὀλίγον εἶναι ἢ τῷ τὸ ὁριζόμενον πολύ· διὸ καὶ λεπτοὶ οἱ χυμοὶ τῶν ὠμῶν, καὶ ψυχροὶ μᾶλλον ἢ θερμοί, καὶ ἄβρωτοι καὶ ἄποτοι. λέγεται δὲ καὶ ἡ ὠμότης ὥσπερ καὶ ἡ πέπανσις, πολλαχῶς. ὅθεν
5 καὶ οὖρα καὶ ὑποχωρήσεις καὶ κατάρροι ὠμοὶ λέ-

[1] ἑαυτὴν Ⓦ O.T. : αὐτὴν cett. Fobes.

[a] This sentence breaks the sequence of thought and seems

then, is what ripening is in the case of fruit, but many other things that have been concocted are said to be ripe ; the process is specifically the same but the term used metaphorically, since, as we remarked earlier, there are no specific names for each type of maturity that occurs when matter is determined by natural heat and cold. In the case of boils and phlegm and the like ripening is the concoction of the moisture in them by their natural heat, for that which does not master material cannot determine it. So when things are ripened, if the material is of an airy nature, the product is watery ; if the material is watery, the product is earthy, and generally what is rare becomes denser. In this process nature assimilates some of the material to itself, and some it rejects

So much for ripening Rawness is its opposite, Rawness which means that it is an inconcoction of the nourishing element in fruit, that is to say, of the undetermined moisture. So rawness is either of an airy or watery nature or a mixture of both : and as ripening is maturity, rawness will be immaturity. Immaturity results from a deficiency of natural heat and its lack of proportion to the moisture that is being ripened. (Nothing moist ripens of itself without the admixture of something dry : for water is the only liquid that does not thicken.[a]) This disproportion occurs either because the amount of heat is small or else because the amount of material being determined is large : hence the juice of raw things is thin, cold rather than hot, and unfit for food or drink. Rawness too, like ripeness, has many senses. Thus urine and excreta and catarrhs are all called raw, the reason for the

out of place here. For what Aristotle says about water *cf.* 383 a 12 and note.

380 b

γονται διὰ τὸ αὐτὸ αἴτιον· τῷ γὰρ μὴ κεκρατῆσθαι ὑπὸ τῆς θερμότητος μηδὲ συνεστάναι ὠμὰ πάντα προσαγορεύεται. πόρρω δὲ προιόντων καὶ κέραμος ὠμὸς καὶ γάλα ὠμὸν καὶ ἄλλα πολλὰ λέγεται, ἐὰν δυνάμενα μεταβάλλειν καὶ συνίστασθαι ὑπὸ θερμότητος ἀπαθῆ ᾖ. διὸ τὸ ὕδωρ ἑφθὸν μὲν λέγεται, ὠμὸν δ' οὔ, ὅτι οὐ παχύνεται.

Πέπανσις μὲν οὖν καὶ ὠμότης εἴρηται τί ἐστιν, καὶ διὰ τί ἐστιν ἑκάτερον αὐτῶν.

Ἕψησις δ' ἐστὶν τὸ μὲν ὅλον πέψις ὑπὸ θερμότητος ὑγρᾶς τοῦ ἐνυπάρχοντος ἀορίστου ἐν τῷ ὑγρῷ, λέγεται δὲ τοὔνομα κυρίως μόνον ἐπὶ τῶν ἑψομένων. τοῦτο δ' ἂν εἴη, ὥσπερ εἴρηται, πνευματῶδες ἢ ὑδατῶδες. ἡ δὲ πέψις γίγνεται ἀπὸ τοῦ ἐν τῷ ὑγρῷ πυρός· τὸ γὰρ ἐπὶ τῶν τηγάνων ὀπτᾶται (ὑπὸ γὰρ τοῦ ἔξωθεν θερμοῦ πάσχει, ἐν ᾧ δ' ἐστὶν ὑγρῷ, ποιεῖ ἐκεῖνο μᾶλλον ξηρόν, εἰς αὐτὸ ἀναλαμβάνον), τὸ δ' ἑψόμενον τοὐναντίον ποιεῖ (ἐκκρίνεται γὰρ ἐξ αὐτοῦ τὸ ὑγρὸν ὑπὸ τῆς ἐν τῷ ἔξω ὑγρῷ θερμασίας)· διὸ ξηρότερα τὰ ἑφθὰ τῶν ὀπτῶν· οὐ γὰρ ἀνασπᾷ εἰς ἑαυτὰ τὸ ὑγρὸν τὰ ἑψόμενα· κρατεῖ γὰρ ἡ ἔξωθεν θερμότης τῆς ἐντός· εἰ δ' ἐκράτει ἡ ἐντός, εἶλκεν ἂν εἰς ἑαυτήν.

Ἔστιν δ' οὐ πᾶν σῶμα ἑψητόν· οὔτε γὰρ ἐν ᾧ μηδέν ἐστιν ὑγρόν, οἷον ἐν λίθοις, οὔτ' ἐν οἷς ἔνεστι μέν, ἀλλ' ἀδύνατον κρατηθῆναι διὰ πυκνότητα, οἷον ἐν τοῖς ξύλοις· ἀλλ' ὅσα τῶν σωμάτων ἔχει ὑγρότητα παθητικὴν ὑπὸ τῆς ἐν τῷ ὑγρῷ πυρώσεως. λέγεται δὲ καὶ χρυσὸς ἕψεσθαι καὶ ξύλον καὶ ἄλλα

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[a] 380 a 29.

[b] *i.e.* the water in which the thing is boiled.

term being applied to them being the same in each case, namely, that the material has not been mastered by the heat or acquired consistency. And if we go farther, brick and milk and many other things also are called raw if they have remained unaffected by heat, though they normally change and acquire consistency when subjected to it. That is why we speak of water being boiled, but not raw, because it does not thicken.

This completes our description of ripening and rawness and of their several causes.

Boiling, as a general term, is concoction by moist heat of the undetermined material present in the moisture of a thing, but the term is properly applicable only to things cooked by boiling. This material, as we have said,[a] is either of an airy or watery nature The concoction arises from the fire in the moisture.[b] For what is cooked in a pan is roasted, being acted upon by the external heat, and in turn acting upon the moisture which contains it, by drying it up and absorbing it into itself: what is boiled, on the other hand, produces the opposite effect, its moisture being drawn out of it by the heat of the moisture surrounding it. This is why boiled food is drier than roast: for things boiled do not draw moisture into themselves, because the external heat is stronger than their own internal heat—if their internal heat were the stronger they would draw it in. Boiling.

Not every body can be boiled. Bodies which contain no moisture, like stones, cannot, nor can bodies which contain moisture but which are too solid for it to be mastered, like wood. Bodies which can are those which contain moisture which is subject to action by the heat in moisture outside them. Of course, gold and wood and many other things are

commonly said to be boiled, but it is not the same kind of process, and is only so called metaphorically as there are no separate words to mark the difference. We also speak of liquids like milk and must being boiled, when the flavour of the liquid undergoes some form of change when heated by the fire surrounding it externally, which thus has an effect on it somewhat similar to boiling as we have defined it. (The end for which things are boiled or concocted is not the same in all cases; in some it is for eating, in others for drinking, in others, again, for some other purpose, as, for instance, we speak of drugs being boiled.) [a] Everything, then, can be boiled which can become denser and smaller and heavier, or of which part can so behave while the remainder behaves in the opposite way, in which case the parts divide, and part thickens, part grows thinner, as milk divides into whey and curds. Olive oil, because it cannot be affected in any of these ways, will not boil by itself. This, then, is what is called concoction by boiling: and it makes no difference whether it takes place in an artificial or a natural vessel, for the cause is the same in all cases.

Scalding [b] is the species of inconcoction opposite to boiling: and the opposite to boiling, and so the primary sense of scalding, will be an inconcoction of the undetermined matter due to a lack of heat in the surrounding liquid. (It has already been stated [c] that lack of heat means presence of cold.) This is caused by another kind of motion, which takes place when the concocting heat is driven out, the lack of heat being due to the amount of cold either in the surrounding liquid or in the thing to be boiled: for Scalding.

[c] 379 a 19.

381 a τῷ ὑγρῷ θερμότητα πλείω μὲν εἶναι ἢ ὥστε μὴ
20 κινῆσαι, ἐλάττω δὲ ἢ ὥστε ὁμαλῦναι καὶ συμπέψαι.
διὸ σκληρότερα μὲν τὰ μεμωλυσμένα γίγνεται τῶν
ἐφθῶν, τὰ δ' ὑγρὰ διωρισμένα μᾶλλον.

Ἕψησις μὲν οὖν καὶ μόλυνσις εἴρηται, καὶ τί
ἐστιν καὶ διὰ τί ἐστιν.

Ὄπτησις δ' ἐστὶν πέψις ὑπὸ θερμότητος ξηρᾶς
καὶ ἀλλοτρίας. διὰ τοῦτο κἂν ἕψων τις ποιῇ μετα-
25 βάλλειν καὶ πέττεσθαι, μὴ ὑπὸ τῆς τοῦ ὑγροῦ θερμό-
τητος ἀλλ' ὑπὸ τῆς τοῦ πυρός, ὅταν τελεσθῇ, ὀπτὸν
γίγνεται καὶ οὐχ ἑφθόν, καὶ τῇ ὑπερβολῇ προσκε-
καῦσθαι λέγεται· ὑπὸ ξηρᾶς δὲ θερμότητος γίγνεται
ὅταν ξηρότερον γίγνηται ἐπιτελεσθέν. διὸ καὶ τὰ
30 ἐκτὸς ξηρότερα τῶν ἐντός· τὰ δ' ἑφθὰ τοὐναντίον.
καὶ ἔργον ἐπὶ τῶν χειροκμήτων τὸ ὀπτῆσαι μεῖζον
ἢ ἑψῆσαι· χαλεπὸν γὰρ τὰ ἐκτὸς καὶ τὰ ἐντὸς ὁμα-
λῶς θερμαίνειν. ἀεὶ γὰρ τὰ ἐγγύτερον τοῦ πυρὸς
381 b ξηραίνεται θᾶττον, ὥστε καὶ μᾶλλον. συνιόντων
οὖν τῶν ἔξω πόρων οὐ δύναται ἐκκρίνεσθαι τὸ
ἐνυπάρχον ὑγρόν, ἀλλ' ἐγκατακλείεται, ὅταν οἱ
πόροι μύσωσιν. ὄπτησις μὲν οὖν καὶ ἕψησις γί-
γνονται μὲν τέχνῃ, ἔστιν δ', ὥσπερ λέγομεν, τὰ
5 εἴδη καθόλου ταὐτὰ καὶ φύσει· ὅμοια γὰρ τὰ γιγνό-
μενα πάθη, ἀλλ' ἀνώνυμα· μιμεῖται γὰρ ἡ τέχνη
τὴν φύσιν, ἐπεὶ καὶ ἡ τῆς τροφῆς ἐν τῷ σώματι
πέψις ὁμοία ἑψήσει ἐστίν· καὶ γὰρ ἐν ὑγρῷ καὶ

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[a] So we speak of *burning* porridge, which we *boil*.

[b] Aristotle's habit of explaining natural processes in terms of artificial comes out very clearly in this passage: *cf.* ch. 2, note *a* on p. 298, and 379 b 14, 380 a 16, 381 a 10.

in these circumstances the heat in the liquid is too great to cause no change at all but too small to produce uniform concoction So things scalded are harder than things boiled and the moisture in them more discrete.

This completes our account of boiling and scalding, their nature and causes.

Roasting is concoction by extrinsic dry heat. So, even if you cause a thing to change and be concocted by boiling it, yet if the change is due to the heat of the fire and not to the heat in the liquid, when the process is complete the thing is roasted and not boiled, while if it is overdone we say it is burnt [a] : but the cause is dry heat if at the end the thing is drier This is why the outside is drier than the inside of things that have been roasted, while the opposite is true of things that have been boiled And when done artificially, roasting is more difficult than boiling, as it is difficult to heat both outside and inside evenly ; for the parts nearer the fire dry faster and so more thoroughly. When, therefore, the outer pores contract, the moisture contained in the thing cannot escape, but is trapped inside when the pores shut. Roasting and boiling are of course artificial processes, but, as we have said, in nature too there are processes specifically the same ; for the phenomena are similar though we have no terms for them For human operations imitate natural.[b] So the digestion [c] of food in the body is similar to boiling, for it takes Roasting.

[c] I have translated *πέψις* by the narrower term "digestion" here, rather than the wider term "concoction" used to translate it elsewhere, as Aristotle is in fact talking of digestion. But the fact that he uses the same word for both shows that he thinks that digestion is to be explained as a form of *cooking*.

381 b θερμῷ ὑπὸ τῆς τοῦ σώματος θερμότητος γίγνεται. καὶ ἀπεψίαι ἔνιαι ὅμοιαι τῇ μολύνσει καὶ ζῷον
10 οὐκ ἐγγίγνεται ἐν τῇ πέψει, ὥσπερ τινές φασιν, ἀλλ' ἐν τῇ ἀποκρίσει σηπομένῃ ἐν τῇ κάτω κοιλίᾳ, εἶτ' ἐπανέρχεται ἄνω· πέττεται μὲν γὰρ ἐν τῇ ἄνω κοιλίᾳ, σήπεται δ' ἐν τῇ κάτω τὸ ἀποκριθέν· δι' ἣν δ' αἰτίαν, εἴρηται ἐν ἑτέροις.

Ἡ μὲν οὖν μόλυνσις τῇ ἑψήσει ἐναντίον· τῇ δὲ
15 ὡς ὀπτήσει λεγομένῃ πέψει ἔστι μέν τι ἀντικείμενον ὁμοίως, ἀνωνυμώτερον δέ. εἴη δ' ἂν οἷον εἰ γένοιτο στάτευσις ἀλλὰ μὴ ὄπτησις δι' ἔνδειαν θερμότητος, ἢ συμβαίη ἂν ἢ δι' ὀλιγότητα τοῦ ἔξω πυρὸς ἢ διὰ πλῆθος τοῦ ἐν τῷ ὀπτωμένῳ ὕδατος· τότε γὰρ
20 πλείων μέν ἐστιν ἢ ὥστε μὴ κινῆσαι, ἐλάττων δὲ ἢ ὥστε πέψαι.

Τί μὲν οὖν ἐστι πέψις καὶ ἀπεψία, καὶ πέπανσις καὶ ὠμότης, καὶ ἕψησις καὶ ὄπτησις καὶ τἀναντία τούτοις, εἴρηται.

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[a] The reference is uncertain.

CHAPTER IV

ARGUMENT

The passive factors, moist and dry (i.e. *in practice water and earth as the elements in which these qualities predominate*), *are necessary constituents of all physical bodies, whose characteristics vary according to the predominance of one or the*

381 b 23 Τῶν δὲ παθητικῶν, τοῦ ὑγροῦ καὶ τοῦ ξηροῦ, λεκτέον τὰ εἴδη.

place under the influence of the heat of the body in a hot and moist medium. And some forms of indigestion are like scalding. And it is not true that worms are generated in the process of digestion as some say; they are generated in the excrement which decays in the lower belly, and subsequently make their way upwards. For digestion takes place in the upper belly and the excrement decays in the lower. The reason for this we have explained elsewhere.[a]

Now scalding is the opposite to boiling, and there is a process similarly opposed to the form of concoction we have called roasting, but it is less easy to find a term for it. It is the sort of thing you will find happening when a thing gets scorched and not properly roasted, as a result of lack of heat caused either through a deficiency of the external fire or an undue amount of water in the thing to be roasted: for then the amount of heat is too great to give rise to no change but too small to concoct properly. The opposite to roasting.

So much for concoction and inconcoction, for ripeness and rawness, and for boiling and roasting and their opposites.

CHAPTER IV

ARGUMENT (*continued*)

other (381 b 23—382 a 8). *So hardness and softness are the primary qualities, anything whose surface does not yield being hard, anything whose surface does yield being soft* (382 a 8-21).

We must now describe the forms taken by the passive factors, moist and dry.

381 b

Εἰσὶν δ' αἱ μὲν ἀρχαὶ τῶν σωμάτων αἱ παθητικαὶ
25 ὑγρὸν καὶ ξηρόν, τὰ δ' ἄλλα μεικτὰ μὲν ἐκ τούτων,
ὁποτέρου δὲ μᾶλλον, τούτου μᾶλλον τὴν φύσιν
ἐστίν, οἷον τὰ μὲν ξηροῦ μᾶλλον τὰ δ' ὑγροῦ.
πάντα δὲ τὰ μὲν ἐντελεχείᾳ ἔσται, τὰ δ' ἐν τῷ
ἀντικειμένῳ ἔχει δ' οὕτως τῆξις πρὸς τὸ τηκτόν.
ἐπεὶ δ' ἐστὶν τὸ μὲν ὑγρὸν εὐόριστον, τὸ δὲ ξηρὸν
30 δυσόριστον, ὅμοιόν τι τῷ ὄψῳ καὶ τοῖς ἡδύσμασι
πρὸς ἄλληλα πάσχουσι· τὸ γὰρ ὑγρὸν τῷ ξηρῷ
αἴτιον τοῦ ὁρίζεσθαι, καὶ ἑκάτερον ἑκατέρῳ οἷον
382 a κόλλα γίγνεται, ὥσπερ καὶ Ἐμπεδοκλῆς ἐποίησεν
ἐν τοῖς φυσικοῖς "ἄλφιτον ὕδατι κολλήσας." καὶ
διὰ τοῦτο ἐξ ἀμφοῖν ἐστιν τὸ ὡρισμένον σῶμα.
λέγεται δὲ τῶν στοιχείων ἰδιαίτατα ξηροῦ μὲν γῆ,
ὑγροῦ δὲ ὕδωρ. διὰ τοῦτο ἅπαντά τε τὰ ὡρισμένα
5 σώματα ἐνταῦθα οὐκ ἄνευ γῆς καὶ ὕδατος (ὁποτέρου δὲ πλέον, κατὰ τὴν δύναμιν τούτου ἕκαστον
φαίνεται)· καὶ ἐν γῇ καὶ ἐν ὕδατι ζῷα μόνον ἐστίν,
ἐν ἀέρι δὲ καὶ πυρὶ οὐκ ἔστιν, ὅτι τῶν σωμάτων
ὕλη ταῦτα. τῶν δὲ σωματικῶν παθημάτων ταῦτα
πρῶτα ἀνάγκη ὑπάρχειν τῷ ὡρισμένῳ, σκληρότητα
10 ἢ μαλακότητα· ἀνάγκη γὰρ τὸ ἐξ ὑγροῦ καὶ ξηροῦ
ἢ σκληρὸν εἶναι ἢ μαλακόν. ἔστι δὲ σκληρὸν μὲν
τὸ μὴ ὑπεῖκον εἰς αὑτὸ κατὰ τὸ ἐπίπεδον, μαλακὸν
δὲ τὸ ὑπεῖκον τῷ μὴ ἀντιπεριίστασθαι· τὸ γὰρ ὕδωρ
οὐ μαλακόν· οὐ γὰρ ὑπείκει τῇ θλίψει τὸ ἐπίπεδον

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[a] *Cf. De Gen. et Corr.* ii. 2, 329 b 30-32 and Joachim, *ad loc.* [b] Diels 31 B 34.

[c] *De Gen. et Corr.* ii. 3, 331 a 3-6, says that air is characteristically moist (*ὑγρόν*), water characteristically cold: yet *De Gen. et Corr.* ii. 8, 334 b 34, implies that water is character-

The passive elements of physical bodies are moist and dry and all bodies are compounds of them, the nature of the body varying according as to which predominates, dry doing so in some cases, moist in others. And all will exist either actually or in the opposite sense, potentially: this, for example, is the relationship borne by the process of melting to the capacity for being melted. The moist is unresistant, the dry resistant,[a] and their mutual relationship is therefore something like that of a dish and its seasoning: for the moist causes the dry to take shape, and each serves as a kind of glue to the other, as Empedocles says, in his poem *On Nature*, "gluing meal together with water" [b] So the body formed is a compound of both. And of the four elements earth is regarded as having the most specific characteristics of dry, water of moist.[c] It is for this reason that all definite physical bodies in our world require earth and water for their composition (and each body manifests the properties of the one which predominates in it), and that animals exist only on land and in water, which are the matter from which their bodies are compounded, but not in air or fire. Of the qualities of body hardness or softness are those which must primarily belong to a determinate thing, for anything compounded of moist and dry must be either hard or soft. Hard is anything whose surface does not yield inwards, soft is anything whose surface yields but not by displacement; for water is not soft, and its surface does not yield downwards to pressure, but

istically moist, and this is certainly the doctrine of the *Meteorologica* as a whole. Perhaps too much stress should not be laid on what Aristotle says in *De Gen et Corr* 331 a 3-6 when he is speaking from a particular point of view. *cf.* Joachim, *ad loc.*, and above, Introduction, pp. xix-xx.

382 a εἰς βάθος, ἀλλ' ἀντιπεριίσταται. ἁπλῶς μὲν οὖν
15 σκληρὸν ἢ μαλακὸν τὸ ἁπλῶς τοιοῦτον, πρὸς
ἕτερον δὲ τὸ πρὸς ἐκεῖνο τοιοῦτον πρὸς μὲν οὖν
ἄλληλα ἀόριστά ἐστιν τῷ μᾶλλον καὶ ἧττον· ἐπεὶ
δὲ πρὸς τὴν αἴσθησιν πάντα κρίνομεν τὰ αἰσθητά,
δῆλον ὅτι καὶ τὸ σκληρὸν καὶ τὸ μαλακὸν ἁπλῶς
πρὸς τὴν ἁφὴν ὡρίκαμεν, ὡς μεσότητι χρώμενοι
20 τῇ ἁφῇ· διὸ τὸ μὲν ὑπερβάλλον αὐτὴν σκληρόν, τὸ
δ' ἐλλεῖπον μαλακὸν εἶναί φαμεν.

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[a] *Cf.* Book I. ch. 12, note *b* on p 82.
[b] *Cf. De Anima* II. 11, 423 b 27 ff.

CHAPTER V

ARGUMENT

Any self-contained body must be hard or soft : whatever is hard or soft is a solid, so we must discuss solidification. This also we shall find to be due to the two active properties,

382 a 22 Ἀνάγκη δὲ σκληρὸν ἢ μαλακὸν εἶναι τὸ ὡρισ-
μένον σῶμα οἰκείῳ ὅρῳ (ἢ γὰρ ὑπείκει ἢ μή)· ἔτι
πεπηγὸς εἶναι (τούτῳ γὰρ ὁρίζεται)· ὥστ' ἐπεὶ πᾶν
25 μὲν τὸ ὡρισμένον καὶ συνεστὸς ἢ μαλακὸν ἢ
σκληρόν, ταῦτα δὲ πήξει ἐστίν, ἅπαντ' ἂν εἴη τὰ
σώματα τὰ σύνθετα καὶ ὡρισμένα οὐκ ἄνευ πήξεως.
πήξεως οὖν πέρι ῥητέον.

Ἔστιν δὴ τὰ αἴτια τὰ παρὰ τὴν ὕλην δύο, τό τε
ποιοῦν καὶ τὸ πάθος (τὸ μὲν οὖν ποιοῦν ὡς ὅθεν ἡ
30 κίνησις, τὸ δὲ πάθος ὡς εἶδος)· ὥστε καὶ πήξεως
καὶ διαχύσεως, καὶ τοῦ ξηραίνεσθαι καὶ τοῦ
ὑγραίνεσθαι. ποιεῖ δὲ τὸ ποιοῦν δυσὶ δυνάμεσι,

is merely displaced.[a] Things which possess these characteristics without qualification are hard and soft absolutely; things which possess them in relation to something else are hard and soft relatively. Degrees of hardness and softness are indefinable with relation to each other; but since we judge all sensible qualities by sensation, it is clear that both hard and soft are defined absolutely with reference to touch, which we use as a mean saying that what exceeds it is hard and what falls short of it is soft.[b]

CHAPTER V

ARGUMENT (*continued*)

heat and cold (382 a 22–b 1). *Drying is a form of solidification, and is due to heat or cold* (382 b 1-27).

Solidification

A BODY defined by its own limit must be either hard or soft, for it either yields or does not. Further, it must be solid; for this gives it its definite limits. So, since every definite and formed body is either soft or hard, and softness and hardness are the result of solidification, no composite and definite thing can exist without solidification. We must therefore discuss solidification.

Now there are two causes besides matter, the efficient and the qualitative, the efficient being the source of movement or change, the qualitative being the formal element. This will apply to solidification and dispersal and to drying and moistening. The efficient cause acts through two properties and the

382 a καὶ πάσχει παθήμασιν δυσίν, ὥσπερ εἴρηται· ποιεῖ μὲν θερμῷ καὶ ψυχρῷ, τὸ δὲ πάθος ἢ ἀπουσίᾳ ἢ
382 b παρουσίᾳ θερμοῦ ἢ ψυχροῦ.

Ἐπεὶ δὲ τὸ πήγνυσθαι ξηραίνεσθαί πώς ἐστιν, περὶ τούτου εἴπωμεν πρῶτον.[1] τὸ δὴ[2] πάσχον ἢ ὑγρὸν ἢ ξηρὸν ἢ ἐκ τούτων. τιθέμεθα δὲ ὑγροῦ σῶμα ὕδωρ, ξηροῦ δὲ γῆν· ταῦτα γὰρ τῶν ὑγρῶν
5 καὶ τῶν ξηρῶν παθητικά. διὸ καὶ τὸ ψυχρὸν τῶν παθητικῶν μᾶλλον· ἐν τούτοις γάρ ἐστιν· καὶ γὰρ ἡ γῆ καὶ τὸ ὕδωρ ψυχρὰ ὑπόκειται. ποιητικὸν δὲ τὸ ψυχρὸν ὡς φθαρτικὸν ἢ ὡς κατὰ συμβεβηκός, καθάπερ εἴρηται πρότερον· ἐνίοτε γὰρ καὶ κάειν
10 λέγεται καὶ θερμαίνειν τὸ ψυχρόν, οὐχ ὡς τὸ θερμόν, ἀλλὰ τῷ συνάγειν ἢ ἀντιπεριιστάναι τὸ θερμόν. ξηραίνεται δὲ ὅσα ἐστὶν ὕδωρ καὶ ὕδατος εἴδη, ἢ ἔχει ὕδωρ εἴτ' ἐπακτὸν εἴτε συμφυές (λέγω δὲ ἐπακτὸν μὲν οἷον ἐν ἐρίῳ, σύμφυτον δ' οἷον ἐν γάλακτι). ὕδατος δ' εἴδη τὰ τοιάδε, οἶνος, οὖρον,
15 ὀρός, καὶ ὅλως ὅσα μηδεμίαν ἢ βραχεῖαν ἔχει ὑπόστασιν, μὴ διὰ γλισχρότητα· ἐνίοις γὰρ αἴτιον τοῦ μὴ ὑφίστασθαι μηδὲν ἡ γλισχρότης, ὥσπερ ἐλαίῳ ἢ πίττῃ ξηραίνεται δὲ πάντα ἢ θερμαινόμενα ἢ ψυχόμενα, ἀμφότερα δὲ θερμῷ, καὶ ὑπὸ τῆς ἐντὸς θερμότητος ἢ τῆς ἔξω· καὶ γὰρ τὰ τῇ
20 ψύξει ξηραινόμενα, ὥσπερ ἰμάτιον, ἐὰν ᾖ κεχωρισμένον αὐτὸ καθ' αὑτὸ τὸ ὑγρόν, ὑπὸ τοῦ ἐντὸς θερμοῦ συνεξατμίζοντος τὸ ὑγρὸν ξηραίνεται, ἂν ὀλίγον ᾖ τὸ ὑγρόν, ἐξιούσης τῆς θερμότητος ὑπὸ τοῦ περιεστῶτος ψυχροῦ.

[1] ἐπεὶ . . . πρῶτον post ὑγραίνεσθαι a 30 transponit O.T.
[2] δὲ O.T.

[a] Ch. 1, 378 b 21. [b] *e.g.* 347 b 2-7, 348 b 2-8.

thing acted on is affected in virtue of two properties as has been explained[a]: the two properties by which action takes place are heat and cold. and the qualitative effect is produced either by the absence or presence of heat and cold.

Since solidification is a form of drying, let us deal with drying first. The thing acted on is either moist or dry or a mixture of both. Water we regard as a largely moist substance, earth as largely dry: for among substances that can be moist or dry these are passive. And so cold is more on the side of the passive qualities, since it is contained in water and earth, both of which we assume to be cold. But cold is an active property either because it disrupts or incidentally, as explained before[b]; for sometimes cold is said both to burn and heat, not in the way that heat does, but by concentrating and compressing heat[c]. Water and all kinds of watery liquids are affected by drying, as well as all things containing water either extraneous or natural (by extraneous I mean like the water in wool, by natural like the water in milk). The watery liquids are, for example, wine, urine, whey, and generally those which have either no sediment or very little, and yet are not viscous; for some liquids have little sediment because they are viscous, like olive oil and pitch. Things are dried either by being heated or by being cooled, heat internal or external being the active cause in either case. For even things which are dried by cooling, like wet clothes, and in which the water has a separate existence, are dried by their internal heat which, when driven out by the surrounding cold, evaporates the moisture if the amount of it is small.

Drying.

[c] *Cf.* Book I. ch. 12, note *b* on p 82.

382 b Ξηραίνεται μὲν οὖν, ὥσπερ εἴρηται, ἅπαντα ἢ θερμαινόμενα ἢ ψυχόμενα, καὶ πάντα θερμῷ, ἢ τῷ ἐντὸς ἢ τῷ ἐκτὸς συνεξατμίζοντι τὸ ὑγρόν (λέγω δ' ἐκτὸς μὲν ὥσπερ τὰ ἑψόμενα, ἐντὸς δὲ ὅταν ἀφαιρεθέντος ὑφ' ἧς ἔχει θερμότητος ἀναλωθῇ ἀποπνεούσης).

Περὶ μὲν οὖν τοῦ ξηραίνεσθαι εἴρηται.

CHAPTER VI

ARGUMENT

Liquefaction and solidification. Liquefaction is the result either of condensation or of melting · solids are formed either (1) *from watery liquids or* (2) *from water and earth by the action of heat or of cold ; they are liquefied again by the action*

382 b 28 Τὸ δ' ὑγραίνεσθαί ἐστιν ἓν μὲν τὸ ὕδωρ γίγνεσθαι συνιστάμενον, ἓν δὲ τὸ τήκεσθαι τὸ πεπηγός. τού-
30 των δὲ συνίσταται μὲν ψυχόμενον τὸ πνεῦμα· περὶ δὲ τήξεως ἅμα καὶ περὶ πήξεως ἔσται δῆλον. πήγνυται δὲ ὅσα πήγνυται ἢ ὕδατος ὄντα ἢ γῆς καὶ ὕδατος, καὶ ταῦτα ἢ θερμῷ ξηρῷ ἢ ψυχρῷ.
383 a διὸ καὶ λύεται τοῖς ἐναντίοις, ὅσα λύεται τῶν ὑπὸ θερμοῦ παγέντων ἢ ὑπὸ ψυχροῦ· τὰ μὲν γὰρ ὑπὸ ξηροῦ θερμοῦ παγέντα ὑπὸ ὕδατος λύεται, ὅ ἐστιν ὑγρὸν ψυχρόν, τὰ δὲ ὑπὸ ψυχροῦ παγέντα ὑπὸ πυρὸς λύεται, ὅ ἐστιν θερμόν. πήγνυσθαι δ' ἔνια δόξειεν

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[a] " Aristotle does not distinguish in this or the next chapter between solution (*λύεσθαι*) and melting (*τῆξις*) : they are treated indifferently as the correlate of *πῆξις* " (O.T.). An exception is 383 b 7, 12, when a distinction is assumed (see

Drying, then, as we have said, is always due to heat or cold, heat internal or external always being the active cause and evaporating the moisture. By external heat I mean, for example, what happens in boiling, by internal what happens when the moisture is removed and consumed by the action of the thing's own heat as it leaves it.

So much for drying.

CHAPTER VI

ARGUMENT (*continued*)

of the opposite of these two properties to that which caused solidification (382 b 28—383 a 6). (1) *Watery liquids* (383 a 6-13). (2) *Compounds of earth and water,* (a) *in which earth predominates* (383 a 13–b 17).

Liquefaction and solidification due to heat or cold.

LIQUEFACTION takes two forms: the one is condensation into water, the other the melting of a solid. Of these, condensation takes place when air is cooled, while melting will be explained at the same time as solidification. Everything that solidifies is (1) a watery liquid or (2) a compound of water and earth, and the cause is either dry heat or cold. So of things which solidify owing to hot or cold, those that dissolve [a] are dissolved by the opposite property: for those that solidify owing to dry heat are dissolved by water, that is, by moist cold, while those that solidify owing to cold are dissolved by fire, that is, by heat. (Some things would appear indeed to be

note *c* on p 323). In chs. 8 and 9, again, solution and melting are not clearly distinguished: *cf.* ch. 8, note *a* on p. 343.

383 a

ἂν ὑπὸ ὕδατος, ὡς τὸ μέλι τὸ ἐφθόν· πήγνυται δὲ οὐχ ὑπὸ τοῦ ὕδατος, ἀλλ' ὑπὸ τοῦ ἐν αὐτῷ ψυχροῦ.

"Οσα μὲν οὖν ἐστιν ὕδατος, οὐ πήγνυται ὑπὸ πυρός· λύεται γὰρ ὑπὸ πυρός, τὸ δὲ αὐτὸ τῷ αὐτῷ κατὰ ταὐτὸ οὐκ ἔσται αἴτιον τοῦ ἐναντίου. ἔτι τῷ ἀπιέναι τὸ θερμὸν πήγνυται, ὥστε δῆλον ὅτι τῷ εἰσιέναι λυθήσεται· ὥστε ποιοῦντος τοῦ ψυχροῦ πήγνυται. διὸ καὶ οὐ παχύνεται τὰ τοιαῦτα πηγνύμενα· ἡ γὰρ πάχυνσις ὑγροῦ μὲν ἀπιόντος γίγνεται, τοῦ ξηροῦ δὲ συνισταμένου· ὕδωρ δὲ τῶν ὑγρῶν οὐ παχύνεται μόνον.[1]

"Οσα δὲ κοινὰ γῆς καὶ ὕδατος, καὶ ὑπὸ πυρὸς πήγνυται καὶ ὑπὸ ψυχροῦ, παχύνεται δὲ ὑπ' ἀμφοῖν ἔστι μὲν ὡς τὸν αὐτὸν τρόπον, ἔστι δ' ὡς ἄλλως, ὑπὸ μὲν θερμοῦ τὸ ὑγρὸν ἐξάγοντος (ἐξατμίζοντος γὰρ τοῦ ὑγροῦ παχύνεται τὸ ξηρὸν καὶ συνίσταται), ὑπὸ δὲ ψυχροῦ τὸ θερμὸν ἐκθλίβοντος, μεθ' οὗ τὸ ὑγρὸν συναπέρχεται συνεξατμίζον. ὅσα μὲν οὖν μαλακὰ ἀλλὰ μὴ ὑγρά, οὐ παχύνεται ἀλλὰ πήγνυται ἐξιόντος τοῦ ὑγροῦ, οἷον ὁ ὀπτώμενος κέραμος· ὅσα δὲ ὑγρὰ τῶν μεικτῶν, καὶ παχύνεται, οἷον γάλα. πολλὰ δὲ καὶ ὑγραίνεται πρῶτον, ὅσα ἢ παχέα ἢ σκληρὰ ὑπὸ ψυχροῦ προϋπῆρχεν ὄντα, ὥσπερ καὶ ὁ κέραμος τὸ πρῶτον ὀπτώμενος ἀτμίζει καὶ μαλακώτερος γίγνεται· διὸ καὶ διαστρέφεται ἐν ταῖς καμίνοις.

[1] ὕδωρ . . . μόνον alio quo traiciendum censet Thurot.

[a] These words seem to be a parenthesis. Contrast ch. 8, 385 b 1 ff. and *cf. Hist. An.* v. 22, 354 a 6.

[b] If any sense is to be made of this sentence, ὕδωρ must be taken (as by the O.T.) as = τὰ ὕδατος. Aristotle is distinguish-

solidified by water, for instance, boiled honey: but in fact it is not the water but the cold in the water which causes it to solidify.) [a]

(1) Watery liquids. (1) Watery liquids, then, are not solidified by fire, for they are dissolved by fire, and the same cause operating on the same substance in the same way cannot produce opposite effects. Besides, it is decrease of heat that solidifies them, and so, clearly, increase of heat will liquefy them; it follows, therefore, that cold is what causes solidification This is why watery liquids when they solidify do not increase in density, for increase in density takes place when the moisture in a thing evaporates and its dry constituents are packed closer, and only watery fluids do not increase in density.[b]

(2) Compounds of earth and water: (2) Compounds of earth and water are solidified both by fire and by cold, and are also increased in density by both, their mode of operation being in some respects the same, in others different. Heat draws out the moisture, and when the moisture evaporates the dry constituents increase in density and pack closer; cold expels the heat and the moisture evaporates and passes off with it. So things that are soft but not moist do not increase in density when moisture leaves them but solidify, like clay when baked: but compounds that are moist, like milk, do increase in density. And bodies which have been made dense or hard by cold often become moist at first when heated, like clay again, which when baked steams at first and becomes softer (which is why it sometimes becomes distorted in the kiln).

ing between solidification and thickening or increase in density, and says that watery liquids are liable to the first but not to the second.

383 a "Οσα μὲν οὖν ὑπὸ ψυχροῦ πήγνυται τῶν κοινῶν γῆς καὶ ὕδατος, πλέον δὲ ἐχόντων γῆς, τὰ μὲν τῷ τὸ θερμὸν ἐξεληλυθέναι πηγνύμενα, ταῦτα τήκεται θερμῷ εἰσιόντος πάλιν τοῦ θερμοῦ, οἷον ὁ πηλὸς
30 ὅταν παγῇ· ὅσα δὲ διὰ ψύξιν, καὶ τοῦ θερμοῦ συνεξατμίσαντος ἅπαντος, ταῦτα δὲ ἄλυτα μὴ ὑπερβαλλούσῃ θερμότητι, ἀλλὰ μαλάττεται, οἷον σίδηρος καὶ κέρας. τήκεται δὲ καὶ ὁ εἰργασμένος σίδηρος, ὥστε ὑγρὸς γίγνεσθαι καὶ πάλιν πήγνυσθαι. καὶ τὰ στομώματα ποιοῦσιν οὕτως· ὑφίσταται γὰρ καὶ
383 b ἀποκαθαίρεται κάτω ἡ σκωρία· ὅταν δὲ πολλάκις πάθῃ καὶ καθαρὸς γένηται, τοῦτο στόμωμα γίγνεται. οὐ ποιοῦσι δὲ πολλάκις αὐτὸ διὰ τὸ ἀπουσίαν γίγνεσθαι πολλὴν καὶ τὸν σταθμὸν ἐλάττω ἀποκαθαιρομένου. ἔστιν δ' ἀμείνων σίδηρος ὁ
5 ἐλάττω ἔχων ἀποκάθαρσιν. τήκεται δὲ καὶ ὁ λίθος ὁ πυρίμαχος ὥστε στάζειν καὶ ῥεῖν· τὸ δὲ πηγνύμενον ὅταν ῥυῇ, πάλιν γίγνεται σκληρόν. καὶ αἱ μύλαι τήκονται ὥστε ῥεῖν· τὸ δὲ ῥέον πηγνύμενον τὸ μὲν χρῶμα μέλαν, ὅμοιον δὲ γίγνεται τῇ τιτάνῳ. τήκεται δὲ καὶ ὁ πηλὸς καὶ ἡ γῆ.[1]
10 "Οσα δ' ὑπὸ ξηροῦ θερμοῦ πήγνυται, τὰ μὲν ἄλυτα, τὰ δὲ λυτὰ ὑγρῷ. κέραμος μὲν οὖν καὶ λίθων ἐνίων γένη, ὅσοι ὑπὸ πυρὸς τῆς γῆς συγκαυθείσης γίγνονται, οἷον οἱ μυλίαι, ἄλυτα, νίτρον δὲ καὶ ἅλες λυτὰ ὑγρῷ, οὐ παντὶ δὲ ἀλλὰ ψυχρῷ· διὸ

[1] τήκεται . . . γῆ del. Thurot O.T.

[a] See Note on Ancient Iron Making at the end of this chapter.

Now, of the compounds of earth and water in which earth predominates and which are solidified by cold, those that solidify because the heat has left them melt when the heat returns to them again, like frozen mud; but those that solidify because of cold and the evaporation of all their heat are indissoluble save by excessive heat, but can be softened, like iron and horn. Wrought iron indeed will melt and grow soft, and then solidify again And this is the way in which steel is made.[a] For the dross sinks to the bottom and is removed from below, and by repeated subjection to this treatment the metal is purified and steel produced. They do not repeat the process often, however, because of the great wastage and loss of weight in the iron that is purified But the better the quality of the iron the smaller the amount of impurity. Pyrimachus stone will also melt and form drops and become fluid: when it solidifies after having been fluid it regains its former hardness. Millstones[b] too melt and become fluid: and when they solidify again afterwards they are black in colour but like lime in texture. [Mud and earth also melt.] (a) in which earth predominates;

Things solidified by dry heat are some of them altogether insoluble, some of them soluble by liquid. Earthenware and some kinds of stone which are made of earth calcined by fire, like millstones, are insoluble[c]: but soda[d] and salt are soluble in liquid, not in all liquid but only in cold. So they melt in water

[b] Millstones were often made of various kinds of lava.

[c] There is no *prima facie* contradiction between this and l 7 above. Millstones can be melted by fire but are insoluble in water. Yet the μυλίαι of 383 b 12, having been solidified by heat (383 b 10), can hardly be the same as the μύλαι of 383 b 7 which have solidified by cold (383 a 26).

[d] νίτρον = sodium carbonate.

383 b

ὕδατι καὶ ὅσα ὕδατος εἴδη τήκεται, ἐλαίῳ δ' οὐ
15 τήκεται· τῷ γὰρ ξηρῷ θερμῷ ἐναντίον ψυχρὸν
ὑγρόν. εἰ οὖν ἔπηξεν θάτερον, θάτερον λύσει· οὕτω
γὰρ τἀναντία ἔσται αἴτια τῶν ἐναντίων.

NOTE ON ANCIENT IRON MAKING [a]

383 A 32–B 5

In order to understand this passage, an interesting and apparently neglected one in the history of ancient metallurgy, it is necessary to know something of the method by which iron was produced in the ancient world.

In what follows, I have been guided especially by the following articles: H. C. Richardson, "Iron, Prehistoric and Ancient," *American Journal of Archaeology*, xxxviii (1934), R. J. Forbes, "The Coming of Iron," *Jaarbericht No. 9 van het voraziatischegyptisch gezelschap "ex Oriente Lux"*; Campbell and Thum, "Ancient Iron," *Metal Progress*, vol. 20 (1931); Rudolf Schaur, "Entwicklungsgeschichte der Hochofen in Steiermark," *Stahl und Eisen*, xlix (April 1929); article *s.v.* "ferrum" in Daremberg-Saglio, *Dictionnaire des antiquités grecques et romaines*. An exhaustive bibliography can be found in R. J. Forbes, *Bibliographia Antiqua, Philosophia Naturalis ii*, part J (Leiden, 1942).[b]

To-day *iron* is produced in the blast furnace, in which the fuel is coke and the ore is completely liquefied. The product of the blast furnace is pig-iron, which has a high carbon content and is therefore very brittle. *Steel* is produced by a further process in which the pig-iron is again made molten and its carbon content reduced, steel being, in fact, iron with a particular range of carbon content (approximately 0·25% to 1·5%). The two steel-making processes now in common use are the Bessemer process and the Siemens open-hearth process; it is unnecessary to enter here into details of either process, the purpose of both being to reduce the carbon

[a] I am very grateful to Mr. Herbert Maryon of the British Museum for advice and help in writing this note

[b] To this should now be added his *Metallurgy in Antiquity* (Leiden, Brill, 1950).

and the watery liquids but not in olive oil. For moist cold is opposite to dry heat. and what one solidifies the other will dissolve ; for opposite causes will thus produce opposite effects.

content of the raw material (pig-iron or pig-iron and scrap iron) sufficiently to make steel. In the blast furnace (and in the Siemens furnace) certain impurities in the charge also liquefy to form a molten " slag " or " gangue " which floats on top of the metal and can be run off separately from it.

The method of making iron in the ancient world was entirely different. The fuel used was charcoal ; and in the charcoal furnaces of the ancient world it was impossible to reach the temperature at which iron melts (1600° C.). The blast furnace, which can reach this temperature, was not developed until the end of the Middle Ages, and even after its invention the possibilities of the new method were limited so long as charcoal remained the fuel ; it was not until 1735 that Abraham Darby of Colebrooke in Shropshire perfected the coke blast furnace which made iron production on a large scale possible. The ancient charcoal furnace was, by comparison, a very simple affair. It consisted of a shallow excavation, perhaps two feet deep, whose sides were built up with turf and stone to a height of two or three feet above ground level and lined with some sort of refractory clay. There was a channel which ran into the bottom of the excavation and through which air could reach the furnace, which to facilitate the construction was commonly built on the side of a hill facing the prevailing wind. The ore was broken up small and charged into the furnace with the charcoal. Bellows were sometimes used to raise the heat, but the furnace was often allowed to burn with a natural draught only. The ore did not become molten but did become pasty and gradually coagulate This process took some 8-12 hours. At the end of it the furnace was broken open, and the iron " bloom " which had formed as a result of the smelting process was removed. This bloom still contained many impurities, the dross, gangue or slag. The melting-point of the slag is lower than that of the ore, and can be still further reduced by the addition of suitable fluxes, which the ancients may have used.

It would therefore liquefy first, and find its way to the lower part of the furnace. Next the heavier iron would trickle down, sink through the slag and gradually form a bloom at the bottom of the furnace, with the slag next above it and the infusible remainder of the ore on top. When the furnace was opened, the bloom would be raked from its position at the bottom and the slag would run or fall or be knocked off it. But much of the slag would, nevertheless, remain adhering to or included in the bloom, and this would be, so far as possible, forced out or knocked off by hammering or forging. In order to remove it more completely the bloom would be reheated and reforged a number of times, but complete removal would hardly be possible, and specimens of ancient iron that have been analysed still contain much slag.

The iron bloom that was finally produced after hammering would, if the iron remained pure, be *wrought iron*. But wrought iron has a very low carbon content and is therefore soft and unsuitable for tools. The problem of the ancient iron-worker was thus the opposite of that of the modern steel-maker: the modern steel-maker has to take the carbon *out* of his raw material (pig-iron) in order to toughen it; the ancient iron-worker had to get carbon *into* his iron so that it could be hardened for tools and weapons. This carburization was effected in the process of repeated reheating; for the iron bloom would pick up carbon from the charcoal fuel, and specimens of ancient iron in fact show a carbon content equivalent to that of mild steel. But the process of carburization was a tricky one, and its results uncertain: and it seems unlikely that the ancient iron-workers really understood it, though they knew quite empirically that repeated reheating did produce an iron or mild steel that could be used for tools and weapons. Hence the quality of the ore was an important factor as some ores, especially those containing manganese, more easily produced iron of the requisite quality when treated by this method than others. The ores of Noricum were especially suited to produce a good quality metal by ancient methods, and that area (the seat of the Halstatt civilization) remained celebrated for its iron throughout the Greco-Roman period.

To render the iron or mild steel so produced hard enough for tool purposes, it was necessary to quench it in water from a white heat. This process was certainly known to the Greeks, and passing reference to it is not uncommon. It is

effective only when the iron has a certain minimum carbon content. hence the importance of the carburization process without which iron will not harden enough to use for tools and weapons. There are, therefore, two main stages in ancient iron-working: (*a*) the smelting of the ore and the production of a bloom of forgeable iron; (*b*) the forging of the iron bloom so produced into a tool or weapon with the quenching as its final stage. (Tempering may have been known to the Romans, but can be ignored for our present purpose.)

It remains to interpret the present passage (383 a 32–b 5) in terms of ancient methods By *εἰργασμένος σίδηρος* (" wrought iron "), Aristotle presumably refers to the produce of the iron furnace, the bloom that has been forged or " wrought." It is doubtful if any ancient furnace could have melted this (even though its melting-point would be less than that of pure iron), and no ancient smith would have wished to do so, for the casting of iron was unknown in the ancient world. Though, therefore, Aristotle speaks of the iron "melting" (*τήκεται* l. 32), he probably does not mean complete liquefaction. In the previous line he speaks of iron as softening (*μαλάττεται* l. 31), and *ὑγρός* (l. 33) can be used of substances that are soft and pliant as well as of those that are liquid Aristotle should therefore be understood to mean that " wrought iron " when heated will become soft and pliable rather than that it will become liquid.

It is not immediately obvious to which of the two main stages of the iron-making process defined above the remainder of the passage refers. The critical word is *στόμωμα* (" steel "). The word is not common in classical authors, as reference to L&S[9] and Stephanus will show.[a] Basically it seems to mean the capacity of steel to take an edge (*cf.* Latin *acies*) : so *στόμα* is used (*e.g.* by Homer, *Il.* xv. 389) of the *edge* or *point* of a weapon. But ancient iron would only take an edge when it had been hardened by quenching · so L&S[9] give " hardened iron," " steel," as the meaning, L&S[8] " iron hardened to take a sharp edge," and we find the connexion of *στόμωμα* with quenching explicitly made by Plutarch, *Moralia* 73 c : *ὥσπερ ὁ σίδηρος πυκνοῦται τῇ περιψύξει καὶ δέχεται τὴν στόμωσιν ἀνεθεὶς πρῶτον ὑπὸ θερμότητος καὶ μαλακὸς γενόμενος, οὕτω τοῖς φίλοις διακεχυμένοις καὶ*

[a] The only occurrence before the 4th century is in a fragment of Cratinus. fr 247 Kock, Pollux 10 186 Aristophanes has *στομόω* (*Nub.* 1108, 1110).

θερμοῖς οὖσι ὑπὸ τῶν ἐπαίνων ὥσπερ βαφὴν ἀτρέμα τὴν παρρησίαν ἐπάγειν. Other passages in Plutarch bear this out (*ibid.* 156 B, 943 E, *Lyc.* 9), and so also does a passage from Aetius quoted by Stephanus. Metaphorically στόμωμα is used either with reference to its hardness or to its cutting power (Plutarch, *Mor.* 625 B, 693 A; Arrian, *Tact.* 12. 2, *cf.* Ael. *Tact.* 13. 2: compare Aristophanes' use of στομόω "to harden" in the sense of "to train" *Nub.* 1108, 1110). στόμωμα then means the non-steel product of the ancient furnace after it has been hardened by quenching and made capable of taking a cutting edge.

At first sight, therefore, one would expect our passage to refer to the second main stage of ancient iron making. The smith when making a tool would start with the εἰργασμένος σίδηρος, the iron bloom, and would heat it in his charcoal furnace. He would have to reheat it a number of times, since it would not remain long at a workable heat when taken out of the furnace. But his bloom would, as we have seen, still contain many impurities, and these would melt (as in the iron-furnace, stage (*a*)) and drop off the bloom and be raked away with the ash of the furnace (ὑφίσταται . . . καὶ ἀποκαθαίρεται κάτω 383 a 34). Too frequent reheating would lead to loss of weight, and would be avoided: and the better the iron the less the impurity and the less the loss. Also, though Aristotle could not know this, the bloom would pick up carbon from the charcoal furnace, and so become more suitable for quenching.

But Aristotle makes no mention of quenching, and he may be thinking of the former of the two stages, and using στόμωμα as a general term for iron, which becomes hard after quenching. We must then suppose that he is reminded by his reference to wrought iron of the smelting process which also (καί 383 a 33) depends on the reaction of iron ore to heat. The words ὑφίσταται . . . καὶ ἀποκαθαίρεται κάτω ἡ σκωρία 383 a 34 refer to the slag sinking to the bottom of the furnace and being raked away. Ideler and the O.T. find the words

puzzling because both think in terms of the blast furnace in which the metal *liquefies* and the melted slag floats on top of it. But in the ancient furnace the slag would "sink to the bottom" with the iron. Several reheatings and reforgings are necessary before the impurities are sufficiently removed (πολλάκις παθῇ 383 b 1), and the purer the ore (σίδηρος covering the ore as well as the product) the smaller the amount of impurity to be removed. Too frequent reheating was avoided because of the loss of weight consequent upon it (383 b 2).

The translation of οὐ ποιοῦσι δὲ πολλάκις αὐτό (383 b 2) as "they do not repeat the process often" follows Ideler, St.-Hilaire and O.T. (and is supported by Alex. 207. 23). There is at first sight a contradiction with πολλάκις παθῇ "frequent subjection to this treatment" (383 b 1), since both contexts refer to the process of reheating. The contradiction can be resolved by supposing that what Aristotle means is that while reheating was necessary (πολλάκις 383 b 1), it inevitably entailed some loss of metal and so was not repeated unduly often (πολλάκις 383 b 2), not more often, we may suppose, than was absolutely necessary. St.-Hilaire makes the point by translating πολλάκις "plusieurs fois" and "souvent" in the two contexts.

Either interpretation of the passage is consistent with ancient practice: but Aristotle's characteristic brevity makes a decision between them difficult. Nor is there much evidence elsewhere in ancient literature to throw light on the subject. [Arist.] *De Mirab. Ausc.* 48 tells us very little, though it perhaps suggests that the pyrimachus stone (mentioned also here 383 b 5) was used as a flux. I doubt whether, as Richardson suggests, it is evidence for the use of a crucible process. Hippocrates, περὶ Διαίτης i. 13, refers briefly to the process of forging and quenching (possibly to smelting also). And Pliny, *Nat. Hist.* xxxiv, has a number of miscellaneous and not very illuminating remarks. But in the main we must rely on non-literary evidence.

CHAPTER VII

ARGUMENT

Liquefaction and solidification (continued.). Compounds of earth and water, (b) *in which water predominates: the*

383 b 18 Παχύνεται μὲν οὖν ὑπὸ πυρὸς μόνον, ὅσα ὕδατος πλέον ἔχει ἢ γῆς, πήγνυται δέ, ὅσα γῆς. διὸ καὶ τὸ 20 νίτρον καὶ οἱ ἅλες γῆς εἰσιν μᾶλλον, καὶ λίθος καὶ κέραμος.

Ἀπορώτατα δὲ ἔχει ἡ τοῦ ἐλαίου φύσις. εἰ μὲν γὰρ ὕδατος, ἔδει πήγνυσθαι ὑπὸ ψυχροῦ, εἰ δὲ γῆς πλέον, ὑπὸ πυρός· νῦν δὲ πήγνυται μὲν ὑπ' οὐδετέρου, παχύνεται δὲ ὑπ' ἀμφοῖν. αἴτιον δ' ἐστὶν 25 ὅτι ἀέρος ἐστὶν πλῆρες. διὸ καὶ ἐν τῷ ὕδατι ἐπιπολάζει· καὶ γὰρ ὁ ἀὴρ φέρεται ἄνω. τὸ μὲν οὖν ψυχρὸν ἐκ τοῦ ἐνόντος πνεύματος ὕδωρ ποιοῦν παχύνει· ἀεὶ γάρ, ὅταν μειχθῇ ὕδωρ καὶ ἔλαιον, ἄμφοῖν γίγνεται παχύτερον. ὑπὸ δὲ πυρὸς καὶ χρόνου παχύνεται καὶ λευκαίνεται, λευκαίνεται μὲν 30 ἐξατμίζοντος εἴ τι ἐνῆν ὕδατος, παχύνεται δὲ διὰ τὸ μαραινομένου τοῦ θερμοῦ ἐκ τοῦ ἀέρος γίγνεσθαι ὕδωρ. ἀμφοτέρως μὲν οὖν τὸ αὐτὸ γίγνεται πάθος, καὶ διὰ τὸ αὐτό, ἀλλ' οὐχ ὡσαύτως. παχύνεται μὲν οὖν ὑπ' ἀμφοτέρων, οὐ ξηραίνεται δ' ὑπ' οὐδετέρου· οὔτε γὰρ ὁ ἥλιος οὔτε τὸ ψῦχος ξηραίνει· οὐ μόνον 384 a διότι γλίσχρον, ἀλλὰ καὶ διότι ἀέρος ἐστίν. οὐ

CHAPTER VII

ARGUMENT (*continued*)

special case of olive oil (383 b 18—384 a 1). *Liquefaction and solidification of various particular compounds of earth and water discussed* (384 a 2–b 23).

(*b*) IN WHICH WATER PREDOMINATES.

COMPOUNDS which contain more water than earth are only increased in density by fire, but those that contain more earth than water are solidified. Soda and salt, therefore, contain more earth, and also stone and clay.

The nature of olive oil is the most difficult to determine.[a] For if it contained more water, cold should solidify it, if more earth, fire should do so. In fact, however, its density is increased by both, while it is solidified by neither. The reason is that it is full of air, which is why it floats on water, since air naturally moves upwards. Cold therefore increases its density by turning the air in it to water, for when oil and water are mixed the density of the compound is greater than that of either constituent. Oil is also increased in density and turned white by fire and by age: it is turned white because of the evaporation of any water it contained; its density is increased because as its heat fades the air in it is turned to water. The effect, therefore, is the same in either case, and so also is the cause, but it operates in a different way. But while its density is increased both by heat and cold, it is not dried by either (for neither sun nor frost dries it), not only because it is viscous but because it contains air; for it is not dried

[a] *Cf. De Gen. An.* ii. 2, 735 b 13 ff.

384 a ξηραίνεται δὲ [τὸ ὕδωρ][1] οὐδ' ἕψεται ὑπὸ πυρός, ὅτι οὐκ ἀτμίζει διὰ γλισχρότητα.

"Οσα δὲ μεικτὰ ὕδατος καὶ γῆς, κατὰ τὸ πλῆθος ἑκατέρου ἄξιον λέγεσθαι· οἶνος γάρ τις καὶ πήγνυται καὶ ἕψεται, οἷον τὸ γλεῦκος. ἀπέρχεται δὲ ἀπὸ πάντων τῶν τοιούτων ξηραινομένων τὸ ὕδωρ. σημεῖον δ' ὅτι τὸ ὕδωρ· ἡ γὰρ ἀτμὶς συνίσταται εἰς ὕδωρ, ἐάν τις βούληται συλλέγειν· ὥστε ὅσοις λείπεταί τι, τοῦτο γῆς. ἔνια δὲ τούτων καὶ ὑπὸ ψυχροῦ, ὥσπερ εἴρηται, παχύνεται καὶ ξηραίνεται· τὸ γὰρ ψυχρὸν οὐ μόνον πήγνυσιν, ἀλλὰ ξηραίνει μὲν ὕδωρ, παχύνει δὲ τὸν ἀέρα ὕδωρ ποιοῦν· ἡ δὲ πῆξις εἴρηται ξηρασία τις οὖσα. ὅσα μὲν οὖν μὴ παχύνεται ὑπὸ τοῦ ψυχροῦ ἀλλὰ πήγνυται, ὕδατός ἐστι μᾶλλον, οἷον οἶνος καὶ οὖρον καὶ ὄξος καὶ κονία καὶ ὁρός· ὅσα δὲ παχύνεται μὴ ἐξατμίζοντα ὑπὸ πυρός, τὰ μὲν γῆς, τὰ δὲ κοινὰ ὕδατος καὶ ἀέρος, μέλι μὲν γῆς, ἔλαιον δ' ἀέρος. ἔστιν δὲ καὶ τὸ γάλα καὶ τὸ αἷμα ἀμφοῖν μὲν κοινὰ καὶ ὕδατος καὶ γῆς, μᾶλλον δὲ τὰ πολλὰ γῆς, ὥσπερ καὶ ἐξ ὅσων ὑγρῶν νίτρον γίγνεται καὶ ἅλες (καὶ λίθοι δ' ἔκ τινων συνίστανται τοιούτων). διὸ ἐὰν μὴ χωρισθῇ ὁ ὁρός, ἐκκάεται ὑπὸ τοῦ πυρὸς ἑψόμενος. τὸ δὲ γεῶδες συνίσταται καὶ ὑπὸ τοῦ ὀποῦ, ἐάν πως ἕψῃ τις, οἷον οἱ ἰατροὶ ὀπίζοντες. οὕτω δὲ χωρίζεται ὁ ὁρὸς καὶ ὁ τυρός. ὁ δὲ χωρισθεὶς ὁρὸς

[1] del. O.T. τὸ ἔλαιον F H N.

[a] And so are a compound of earth and water, and not "watery liquids," the heading under which wine in general is classified at 382 b 13.

up or boiled off by fire because its viscous character prevents evaporation.

Various examples discussed.

Compounds of water and earth should be classified according to which predominates For some kinds of wine, for example must, solidify when boiled.[a] In all such cases it is the water that is driven off in the process of drying. This is shown by the fact that if you collect the vapour it condenses into water[b]: and so where there is any sediment left it must be earthy. But some of these compounds, as we have said,[c] are also increased in density and dried by cold. For cold not only solidifies, but also dries water and increases density by turning air to water; and solidification we have already[d] described as a kind of drying. Things, therefore, which cold solidifies but does not increase in density, contain more water, like wine, urine, vinegar, lye and whey[e]: and of things which it increases in density (but which are not evaporated by fire), some contain more earth while others are a compound of water and air—honey, for example, contains more earth, oil contains air. Milk and blood are both compounds of earth and water, containing for the most part more earth, as also are the liquids from which soda and salt are formed. Stones are also formed from some liquids of the same kind. So whey, if it has not been separated, will boil away on a fire. The earthy constituent in milk can also be coagulated by rennet, if you boil it in the way doctors do when they curdle it: and this is the way in which the whey and the cheese are commonly separated.

[b] *Cf.* Book II. ch. 3, note *b* on p. 156.

[c] 383 a 13. [d] 382 b 1.

[e] Yet at 382 b 13 wine, urine and whey were classified as "watery liquids" (ὕδατος εἴδη), which should imply that they have no admixture of earth: *cf.* also 384 a 4, 385 b 1.

384 a οὐκέτι παχύνεται, ἀλλ' ἐκκάεται ὥσπερ ὕδωρ. εἰ δέ τι μὴ ἔχει τυρὸν γάλα ἢ ὀλίγον, τοῦτο μᾶλλον ὕδατος καὶ ἄτροφον. καὶ τὸ αἷμα δὲ ὁμοίως· πήγνυται γὰρ τῷ ξηραίνεσθαι ψυχόμενον. ὅσα δὲ μὴ πήγνυται, οἷον τὸ τῆς ἐλάφου, τὰ τοιαῦτα ὕδατος μᾶλλον, καὶ ψυχρὰ ταῦτα. διὸ καὶ οὐκ ἔχει ἵνας· αἱ γὰρ ἶνές εἰσιν γῆς καὶ στερεόν· ὥστε καὶ ἐξαιρεθεισῶν οὐ πήγνυται· τοῦτο δ' ἐστὶν ὅτι οὐ ξηραίνεται· ὕδωρ γὰρ τὸ λοιπόν, ὡς τὸ γάλα τοῦ τυροῦ ἐξαιρεθέντος. σημεῖον δέ· τὰ νοσώδη γὰρ αἵματα οὐ θέλει πήγνυσθαι· ἰχωροειδῆ γάρ, τοῦτο δὲ φλέγμα καὶ ὕδωρ,[1] διὰ τὸ ἄπεπτον εἶναι καὶ ἀκράτητον ὑπὸ τῆς φύσεως. ἔτι δὲ τὰ μὲν λυτά 384 b ἐστιν, οἷον νίτρον, τὰ δὲ ἄλυτα, οἷον κέραμος, καὶ τούτων τὰ μὲν μαλακτά, οἷον κέρας, τὰ δὲ ἀμάλακτα, οἷον κέραμος καὶ λίθος. αἴτιον δ' ὅτι τἀναντία τῶν ἐναντίων αἴτια, ὥστ' εἰ πήγνυται δυοῖν, ψυχρῷ καὶ ξηρῷ, λύεσθαι ἀνάγκη θερμῷ καὶ 5 ὑγρῷ· διὸ πυρὶ καὶ ὕδατι (ταῦτα γὰρ ἐναντία), ὕδατι μὲν ὅσα πυρὶ μόνῳ, πυρὶ δὲ ὅσα ψυχρῷ μόνῳ· ὥστ' εἴ τι ὑπ' ἀμφοῖν συμβαίνει πήγνυσθαι, ταῦτα ἄλυτα μάλιστα. γίγνεται δὲ τοιαῦτα ὅσα θερμανθέντα ἔπειτα τῷ ψυχρῷ πήγνυται· συμβαίνει γάρ, ὅταν τὸ θερμὸν ἐξικμάσῃ ἐξιὸν τὸ πλεῖστον ὑγρόν,[2] συν- 10 θλίβεσθαι πάλιν ὑπὸ τοῦ ψυχροῦ, ὥστε μηδὲ ὑγρῷ διδόναι δίοδον. καὶ διὰ ταῦτα οὔτε τὸ θερμὸν λύει·

[1] interpunxi.

[2] interpunxit O.T. : ἐξιόν, τὸ πλεῖστον Forbes.

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[a] *Cf. De Part. An.* ii. 4: and for the deer in particular *De Part. An.* ii. 4, 650 b 15, *Hist. An.* iii. 6, 515 b 34.

[b] Adopting the O.T.'s punctuation, and taking ἐξικμάσῃ b 9 as transitive: there is indeed no real authority for its use as intransitive, for the only instance, apart from this passage,

Whey when separated will no longer increase in density but boil away like water: and if milk contains little or no cheese, then water predominates in its composition and it is not nutritious. Blood [a] behaves similarly, for it solidifies when dried by cooling. But in kinds of blood that do not solidify, like that of the deer, water predominates and the temperature is cold. Hence they do not contain fibres, fibres being composed of earth and solid. So blood from which fibres have been removed does not solidify, because it will not dry, the residuum being watery, which is what happens to milk when the cheese is removed A proof of this is that diseased blood will not solidify, being serous, that is, made up of phlegm and water, nature having failed to control and concoct it. Again, some compounds are soluble, like soda, others are insoluble, like earthenware, and of these some can be softened, like horn, others cannot, like earthenware and stone. The reason is that opposite causes produce opposite effects, so if the two properties cold and dry cause solidification, it follows that hot and moist cause dissolution. So fire and water are dissolving agents (being opposites), water dissolving what fire alone solidifies, fire what cold alone solidifies, while anything that is solidified by both is least liable to dissolution. For when the heat as it leaves them vaporizes most of their moisture, they become compressed again by the cold and so afford no entrance even to moisture.[b] And for this reason even heat will not dissolve them, for it dis-

given by L&S[9] (*Problems* 930 b 34) may be corrupt (Stephanus suggests that ἐξήτμικε is the correct reading). Fobes' punctuation (following Ideler and Bekker) does not yield the sense clearly required: for, as 383 a 12 shows, it is not τὸ ὑγρόν that is compressed, but τὸ ξηρόν.

384 b ὅσα γὰρ ὑπὸ ψυχροῦ πήγνυται μόνου, ταῦτα λύει· οὔθ' ὑπὸ ὕδατος· ὅσα γὰρ ὑπὸ ψυχροῦ πήγνυται, οὐ λύει, ἀλλ' ὅσα ὑπὸ θερμοῦ ξηροῦ μόνον. ὁ δὲ σίδηρος τακεὶς ὑπὸ θερμοῦ ψυχθεὶς πήγνυται. τὰ δὲ ξύλα ἐστὶν γῆς καὶ ἀέρος· διὸ καυστὰ καὶ οὐ τηκτὰ οὐδὲ μαλακτά, καὶ ἐπὶ τῷ ὕδατι ἐπιπλεῖ, πλὴν ἐβένου· αὕτη δ' οὔ· τὰ μὲν γὰρ ἄλλα ἀέρος ἔχει πλέον, ἐκ δὲ τῆς ἐβένου τῆς μελαίνης διαπέπνευκεν ὁ ἀήρ, καὶ ἔστι πλέον ἐν αὐτῇ γῆς. κέραμος δὲ γῆς μόνον διὰ τὸ ξηραινόμενος παγῆναι κατὰ μικρόν· οὔτε γὰρ τὸ ὕδωρ εἰσόδους ἔχει, δι' ὧν μόνον πνεῦμα ἐξῆλθεν, οὔτε πῦρ· ἔπηξε γὰρ αὐτό.

Τί μὲν οὖν ἐστι πῆξις καὶ τῆξις, καὶ διὰ πόσα καὶ ἐν πόσοις ἐστίν, εἴρηται.

CHAPTER VIII

ARGUMENT

Differentiating qualities of bodies. All bodies thus contain the four primary qualities of heat, cold, wet and dry. They are also differentiated by the ways in which they affect our senses and by certain intrinsic properties (384 b 24—385 a 10). *Eighteen such properties, each grouped with its contrary, are enumerated* (385 a 10-20). *The first two pairs dealt with* (385 a 20–b 5).

Note.—*The compounds with which Aristotle is primarily concerned in the remaining chapters (even when he does not mention them specifically, as in ch.* 11) *are the "homoeomerous" bodies. A substance is homoeomerous if it is homogeneous in the sense of being a chemical compound*

solves only such things as are solidified by cold: nor will water, which will not dissolve things solidified by cold but only those solidified by dry heat. But iron is melted by heat and solidifies when cooled. Wood is composed of earth and air and so is combustible, but not meltable or softenable, and (except for ebony) floats. Ebony does not, for while in other woods there is a greater proportion of air, in black ebony it has been exhaled and the proportion of earth is greater. Earthenware is composed of earth only because when dried it solidifies gradually; neither can water gain entry through pores from which only vapour could escape, nor can fire, which was the solidifying agent.

This completes our account of solidification and melting, their causes and the substances in which they occur.

CHAPTER VIII

ARGUMENT (*continued*)

(μίξις), *as opposed to a mechanical mixture* (σύνθεσις): cf. De Gen. et Corr. *i.* 10, *esp.* 328 a 10 φαμὲν δὲ δεῖν, εἴπερ μέμικται, τὸ μιχθὲν ὁμοιομερὲς εἶναι. *The homoeomerous substances thus play an important part in Aristotle's theory of the physical world. The simplest physical substances are the four elements, analysable in theory but not in fact into combinations of the four prime contraries and prime matter* (De Caelo *iii-iv*, De Gen. et Corr. *ii.* 1-6). *From the four elements the homoeomerous substances are made, comprising all simple homogeneous substances, animal and mineral: from the homoeomerous substances in turn are composed more complex*

(*anhomoeomerous*) *organic and inorganic bodies:* cf 388 a 13 *ff.*, 389 b 27 *ff.*, *and* De Part. An. II 1, 646 a 8-21, De Gen. An. 715 a 8-11. *The distinction between homoeomerous*

334 b 24 Ἐκ δὲ τούτων φανερὸν ὅτι ὑπὸ θερμοῦ καὶ
25 ψυχροῦ συνίσταται τὰ σώματα, ταῦτα δὲ πάχυνοντα καὶ πηγνύντα ποιεῖται τὴν ἐργασίαν αὐτῶν. διὰ δὲ τὸ ὑπὸ τούτων δημιουργεῖσθαι ἐν ἅπασιν ἔνεστι θερμότης, τισὶ δὲ καὶ ψυχρότης ἢ ἐκλείπει. ὥστ' ἐπεὶ ταῦτα μὲν ὑπάρχει διὰ τὸ ποιεῖν, ὑγρὸν δὲ καὶ
30 ξηρὸν διὰ τὸ πάσχειν, μετέχει αὐτῶν τὰ κοινὰ πάντων. ἐκ μὲν οὖν ὕδατος καὶ γῆς τὰ ὁμοιομερῆ σώματα συνίσταται, καὶ ἐν φυτοῖς καὶ ἐν ζῴοις, καὶ τὰ μεταλλευόμενα, οἷον χρυσὸς καὶ ἄργυρος καὶ ὅσα ἄλλα τοιαῦτα, ἐξ αὐτῶν τε καὶ ἐκ τῆς ἀναθυμιάσεως τῆς ἑκατέρου ἐγκατακλειομένης,
335 a ὥσπερ εἴρηται ἐν ἄλλοις. ταῦτα δὲ διαφέρει ἀλλήλων τοῖς τε πρὸς τὰς αἰσθήσεις ἰδίοις ἅπαντα, τῷ ποιεῖν τι δύνασθαι (λευκὸν γὰρ καὶ εὐῶδες καὶ ψοφητικὸν καὶ γλυκὺ καὶ θερμὸν καὶ ψυχρὸν τῷ ποιεῖν τι δύνασθαι τὴν αἴσθησίν ἐστι), καὶ ἄλλοις
5 οἰκειοτέροις πάθεσιν, ὅσα τῷ πάσχειν λέγονται, λέγω δ' οἷον τὸ τηκτὸν καὶ πηκτὸν καὶ καμπτὸν καὶ ὅσα ἄλλα τοιαῦτα· πάντα γὰρ τὰ τοιαῦτα παθητικά, ὥσπερ τὸ ὑγρὸν καὶ τὸ ξηρόν. τούτοις δ' ἤδη διαφέρει ὀστοῦν καὶ σὰρξ καὶ νεῦρον καὶ ξύλον
10 καὶ φλοιὸς καὶ λίθος καὶ τῶν ἄλλων ἕκαστον τῶν ὁμοιομερῶν μὲν φυσικῶν δὲ σωμάτων.

Εἴπωμεν δὲ πρῶτον τὸν ἀριθμὸν αὐτῶν, ὅσα κατὰ δύναμιν καὶ ἀδυναμίαν λέγεται. ἔστιν δὲ τάδε·

Πηκτὸν ἄπηκτον.
Τηκτὸν ἄτηκτον.

and anhomoeomerous is particularly important in biology, where you have the homoeomerous parts (blood, bone, sinew, flesh), the anhomoeomerous parts composed of them (hands, feet, eyes) and finally the complete creature (man, horse).

The qualities of bodies classified

From this it is clear that bodies are formed by heat and cold, which operate by increasing density and solidifying. And because they are manufactured by them, all bodies contain heat and some contain cold in so far as they lack heat. So, since heat and cold are present as active constituents, moist and dry as passive, compound bodies contain them all The homoeomerous bodies, therefore, vegetable and animal, and also the metals,[a] such as gold, silver and the like, are composed of water and earth and of their exhalations when, as has been explained elsewhere,[b] they are enclosed underground. All these bodies differ from each other, firstly, in the particular ways in which they can act on the senses (for a thing is white, fragrant, resonant, sweet, hot or cold in virtue of the way it acts on sensation), and, secondly, in other more intrinsic qualities commonly classed as passive—I mean solubility, solidification, flexibility and the like, all of which, like moist and dry, are passive qualities. It is by these passive qualities that bone, flesh, sinew, wood, bark, stone and all the other natural homoeomerous bodies are differentiated.

and enumerated in pairs.

Let us begin by enumerating them, grouping each property with its converse. They are as follows :

1. Capable or incapable of solidification.
2. Meltable or unmeltable.

[a] τὰ μεταλλευόμενα are said to be a species of ὁμοιομερῆ at 388 a 13.

[b] Book III. ch. 6, 378 a 15 ff.

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Μαλακτὸν ἀμάλακτον.
Τεγκτὸν ἄτεγκτον.
Καμπτὸν ἄκαμπτον.
Κατακτὸν ἀκάτακτον.
Θραυστὸν ἄθραυστον.
Θλαστὸν ἄθλαστον.
Πλαστὸν ἄπλαστον.
Πιεστὸν ἀπίεστον.
Ἑλκτὸν ἄνελκτον.
Ἐλατὸν ἀνήλατον.
Σχιστὸν ἄσχιστον.
Τμητὸν ἄτμητον.
Γλίσχρον ψαθυρόν.
Πιλητὸν ἀπίλητον.
Καυστὸν ἄκαυστον.
Θυμιατὸν ἀθυμίατον.

Τὰ μὲν οὖν πλεῖστα σχεδὸν τῶν σωμάτων τούτοις διαφέρει τοῖς πάθεσιν· τίνα δ' ἕκαστον τούτων ἔχει δύναμιν, εἴπωμεν.

Περὶ μὲν οὖν πηκτοῦ καὶ ἀπήκτου καὶ τηκτοῦ καὶ ἀτήκτου εἴρηται μὲν καθόλου πρότερον, ὅμως δ' ἐπανέλθωμεν καὶ νῦν. τῶν γὰρ σωμάτων ὅσα πήγνυται καὶ σκληρύνεται, τὰ μὲν ὑπὸ θερμοῦ πάσχει τοῦτο τὰ δ' ὑπὸ ψυχροῦ, ὑπὸ μὲν τοῦ θερμοῦ ξηραίνοντος τὸ ὑγρόν, ὑπὸ δὲ τοῦ ψυχροῦ ἐκθλίβοντος τὸ θερμόν. ὥστε τὰ μὲν ἀϋγροῦπουσίᾳ τὰ δὲ θερμοῦ τοῦτο πάσχει, ὅσα μὲν ὕδατος, θερμοῦ, ὅσα δὲ γῆς, ὑγροῦ. τὰ μὲν οὖν ὑγροῦ ἀπουσίᾳ ὑπὸ ὑγροῦ διατήκεται, ἂν μὴ οὕτως συνέλθῃ ὥστε ἐλάττους τοὺς πόρους λειφθῆναι τῶν τοῦ ὕδατος ὄγκων,

3. Softenable or unsoftenable by heat.
4. Softenable or unsoftenable by water.
5. Flexible or inflexible.
6. Breakable or unbreakable.
7. Capable or incapable of fragmentation.
8. Capable or incapable of taking an impression.
9. Plastic or non-plastic.
10. Capable or incapable of being squeezed.
11. Ductile or non-ductile.
12. Malleable or non-malleable.
13. Fissile or non-fissile.
14. Cuttable or uncuttable.
15. Viscous or friable.
16. Compressible or incompressible.
17. Combustible or incombustible
18. Capable or incapable of giving off fumes.

The great majority of bodies are differentiated by these qualities, whose nature we will therefore go on to describe.

(1 and 2) Solidification, melting and their contraries

We have already [a] given a general description of the first two pairs of qualities, but let us return to them again now. Bodies which solidify and harden do so under the influence of cold or heat, heat drying their moisture and cold expelling their heat · they are so affected, in fact, either by lack of moisture or of heat, those in which water predominates by lack of heat, those in which earth predominates by lack of moisture. Bodies so affected by lack of moisture are melted by moisture, unless their composition is such that their pores [b] are too small for the particles of water to enter, as, for instance, earthenware ; but

[a] Chs. 6 and 7.

[b] On Aristotle's use of " pores " in this and the following passages see Introd. p. xvii.

385 a οἷον ὁ κέραμος· ὅσα δὲ μὴ οὕτω, πάντα ὑγρῷ τήκεται, οἷον νίτρον, ἅλες, γῇ ἡ ἐκ πηλοῦ· τὰ δὲ θερμοῦ στερήσει ὑπὸ θερμοῦ τήκεται, οἷον κρύσταλλος, μόλυβδος, χαλκός. ποῖα μὲν οὖν πηκτὰ
385 b καὶ τηκτά, εἴρηται, καὶ ποῖα ἄτηκτα. ἄπηκτα δὲ ὅσα μὴ ἔχει ὑγρότητα ὑδατώδη, μηδὲ ὕδατός ἐστιν, ἀλλὰ πλέον θερμοῦ καὶ γῆς, οἷον μέλι καὶ γλεῦκος (ὥσπερ ζέοντα γάρ ἐστιν), καὶ ὅσα ὕδατος μὲν ἔχει, ἔστιν δὲ πλέον ἀέρος, ὥσπερ τὸ ἔλαιον καὶ ὁ ἄρ-
5 γυρος ὁ χυτός, καὶ εἴ τι γλίσχρον, οἷον ⟨πίττα καὶ⟩[1] ἰξός.

[1] *πίττα καὶ* om. codd. : habent Al Ol.

CHAPTER IX

ARGUMENT

The remaining sixteen properties and their contraries are dealt with in order.

385 b 6 Μαλακτὰ δ' ἐστὶ τῶν πεπηγότων ὅσα μὴ ἐξ ὕδατος, οἷον κρύσταλλος ὕδατος, ἀλλ' ὅσα γῆς μᾶλλον, καὶ μήτ' ἐξίκμασται πᾶν τὸ ὑγρὸν ὥσπερ ἐν νίτρῳ ἢ ἅλσί, μήτ' ἔχει ἀνωμάλως ὥσπερ ὁ κέ-
10 ραμος, ἀλλ' ἢ ἑλκτὰ μὴ ὄντα διαντά, ἢ ἑλατὰ μὴ ὄντα ὕδατος, καὶ μαλακτὰ πυρί, οἷον σίδηρος καὶ κέρας [καὶ ξύλα.][1]

Ἔστι δὲ καὶ τῶν τηκτῶν καὶ τῶν ἀτήκτων τὰ μὲν τεγκτὰ τὰ δὲ ἄτεγκτα, οἷον χαλκὸς ἄτεγκτον, τηκτὸν ὄν, ἔριον δὲ καὶ γῆ τεγκτόν· βρέχεται γάρ.
15 καὶ χαλκὸς μὲν δὴ τηκτόν, οὐχ ὑπὸ ὕδατος δὲ

unless this is so they are all melted by moisture, like soda, salt and dried mud Bodies solidified by deficiency of heat are melted by heat, for instance ice, lead or bronze [a] This deals with bodies capable of solidification and with bodies that will and will not melt. Incapable of solidification are bodies which contain no watery moisture and are not watery, and in which heat and earth predominate rather than water, like honey and must (for they are in a kind of ferment), and also bodies in which, though they contain water, air predominates, like oil, quicksilver and viscous liquids such as pitch and birdlime.

[a] Aristotle uses the same word (*τηκτόν*), both of substances that can be *dissolved* in water (*e.g.* salt) and *melted* by fire.

CHAPTER IX

(3) Softenable by heat.

Solid bodies can be softened by heat if they are not composed of water (as ice is) but are predominantly earthy: their moisture must not have been all evaporated (as in soda or salt) nor be disproportionately small in quantity (as in potter's clay), and if they are either tensile but not absorbent or ductile without a preponderance of moisture, fire will soften them. Examples are iron and horn.

(4) Softenable by water.

Of bodies that can and cannot be melted some can be softened in water, some cannot; thus bronze, which will melt, cannot, but wool and earth can, for they can be soaked. Bronze, of course, though it can be melted, cannot be melted in water: but some

[1] secl. O.T., cf. 384 b 15-16.

things also which can be melted in water cannot be softened, like soda and salt. for nothing is softened in water which does not become softer when soaked. On the other hand, some things which water softens do not melt, like wool and grain. Anything which is earthy and has pores larger than the particles of water and harder than water can be softened by water But bodies that can be melted by water are porous throughout.[a] But why is earth melted and softened by moisture while soda is melted but is not softened? Because soda is porous throughout and so its parts are dispersed at once by water; but in earth the pores alternate and the effect differs according to which set the water enters.

(5) Flexible and inflexible.

Some bodies can be bent and straightened. like reeds and withies; some cannot be bent, like earthenware and stone. Things which cannot be bent and straightened are those which when curved cannot be bent straight and when straight cannot be bent into a curve, bending and straightening being the motion of bending straight or into a curve, for a thing is bent whether it is bent in or out. Bending, therefore, is alteration of shape to convex or concave, length remaining unchanged. If we were to add "or to straight," it would imply that a thing could be simultaneously bent and straight, and it is of course impossible for what is bent to be straight. And if everything that is bent is bent either in or out, and

[a] If the pores remain intact the body is softenable: if they yield the body melts. The latter alternative is expressed rather obscurely in the words τηκτὰ . . . δι' ὅλου (l. 21), with which we must presumably supply ἔχει πόρους from ll. 19-20.

[2] διὰ τί l. 21 . . . τὸ πάθος secludendum censent O.T. Ideler.

386 a

εἰς τὸ κυρτὸν τὸ δ' εἰς τὸ κοῖλον μετάβασις, οὐκ ἂν εἴη καὶ εἰς τὸ εὐθὺ κάμψις, ἀλλ' ἔστι κάμψις καὶ εὔθυνσις ἄλλο καὶ ἄλλο. καὶ ταῦτά ἐστιν καμπτὰ καὶ εὐθυντά, καὶ ἄκαμπτα καὶ ἀνεύθυντα.

Καὶ τὰ μὲν κατακτὰ καὶ θραυστὰ ἅμα ἢ χωρίς, οἷον ξύλον μὲν κατακτόν, θραυστὸν δ' οὔ, κρύσταλλος δὲ καὶ λίθος θραυστόν, κατακτὸν δ' οὔ, κέραμος δὲ καὶ θραυστὸν καὶ κατακτόν. διαφέρει δ', ὅτι κάταξις μέν ἐστιν εἰς μεγάλα μέρη διαίρεσις καὶ χώρισις, θραῦσις δὲ εἰς τὰ τυχόντα καὶ πλείω δυοῖν. ὅσα μὲν οὖν οὕτω πέπηγεν ὥστε πολλοὺς ἔχειν παραλλάττοντας πόρους, θραυστά (μέχρι γὰρ τούτου διίσταται), ὅσα δ' εἰς πολύ, κατακτά, ὅσα δ' ἄμφω, ἀμφότερα.

Καὶ τὰ μὲν θλαστά, οἷον χαλκὸς καὶ κηρός, τὰ δ' ἄθλαστα, οἷον κέραμος καὶ ὕδωρ. ἔστιν δὲ θλάσις ἐπιπέδου κατὰ μέρος εἰς βάθος μετάστασις ὥσει ἢ πληγῇ, τὸ δ' ὅλον ἀφῇ. ἔστιν δὲ τὰ τοιαῦτα καὶ μαλακά,[1] οἷον κηρὸς μένοντος τοῦ ἄλλου ἐπιπέδου κατὰ μέρος μεθίσταται, καὶ σκληρά, οἷον χαλκός. καὶ τὰ[2] ἄθλαστα καὶ σκληρά, οἷον κέραμος (οὐ γὰρ ὑπείκει εἰς βάθος τὸ ἐπίπεδον), καὶ ὑγρά, οἷον ὕδωρ (τὸ γὰρ ὕδωρ ὑπείκει μέν, ἀλλ' οὐ κατὰ μέρος, ἀλλ' ἀντιμεθίσταται). τῶν δὲ θλαστῶν ὅσα μὲν μένει θλασθέντα καὶ εὔθλαστα χειρί, ταῦτα μὲν πλαστά, τὰ δὲ ἢ μὴ εὔθλαστα, ὥσπερ λίθος ἢ ξύλον, ἢ εὔθλαστα μέν, μὴ μένει δὲ ἡ θλάσις, ὥσπερ ἠρίου

[1] μαλακά E O.T. Thurot : μαλακτά Fobes cett.
[2] χαλκός. καὶ τὰ ἄθλαστα O.T. Thurot : χαλκός, καὶ ἄθλαστα Fobes : θλαστὰ alii.

if this means an alteration of shape either to convex or to concave, there is no such process as bending straight, but two different processes, bending and straightening. These, then, are the things that can and cannot be bent and can and cannot be straightened.

(6, 7) Breaking and fragmentation

Some things can be both broken and fragmented, others only one or the other. Thus wood can be broken but not fragmented, ice and stone can be fragmented but not broken, while earthenware can be both fragmented and broken The difference is that breaking is division and separation into large parts, fragmentation into any number of parts greater than two. Things, therefore, that solidify in such a way as to have many alternating pores fragment (the pores allowing this degree of dispersion), and things that have long continuous pores break, while things that have pores of both kinds do both.

(8) Capable of taking an impression.

Some things will take an impression, like bronze and wax, some things cannot, like earthenware and water. An impression is an indentation of part of a thing's surface by pressure or impact, or, generally speaking, by contact; and such things are either soft,[a] like wax, part of whose surface only is indented, or hard, like bronze. Things that cannot take an impression are either hard, like earthenware (for its surface will not yield inwards), or moist, like water (for water yields not by any part of it being indented, but by displacement). Of things that take an impression, those that retain it and are easily moulded by hand are plastic; while those not easily moulded, like stone or wood, or easily moulded but incapable

(9) Plasticity.

[a] *μαλακά* must be the right reading, for the contrast is with *σκληρά*: *cf.* 382 a 10.

386 a ἢ σπόγγου, οὐ πλαστά, ἀλλὰ πιεστὰ ταῦτ' ἐστίν.
ἔστι δὲ πιεστὰ ὅσα ὠθούμενα εἰς αὑτὰ συνιέναι
δύναται, εἰς βάθος τοῦ ἐπιπέδου παραλλάττοντος,
οὐ διαιρουμένου, καὶ ⟨μὴ⟩ μεθισταμένου ἄλλου
ἄλλῳ μορίου, οἷον τὸ ὕδωρ ποιεῖ· τοῦτο γὰρ ἀντι-
386 b μεθίσταται. ἔστι δὲ ὦσις ἡ κίνησις ὑπὸ τοῦ κι-
νοῦντος, ἢ γίγνεται ἀπὸ τῆς ἄψεως· πληγὴ δέ, ὅταν
ἀπὸ τῆς φορᾶς. πιέζεται δὲ ὅσα πόρους ἔχει κενοὺς
συγγενοῦς σώματος· καὶ πιεστὰ ταῦτα ὅσα δύναται
εἰς τὰ ἑαυτῶν κενὰ συνιέναι ἢ εἰς τοὺς ἑαυτῶν
πόρους· ἐνίοτε γὰρ οὐ κενοί εἰσιν εἰς οὓς συνέρχεται,[1]
5 οἷον ὁ βεβρεγμένος σπόγγος (πλήρεις γὰρ αὐτοῦ
οἱ πόροι), ἀλλ' ὧν ἂν οἱ πόροι πλήρεις ὦσι μαλακω-
τέρων ἢ αὐτὸ τὸ πεφυκὸς συνιέναι εἰς αὑτό.[2]
πιεστὰ μὲν οὖν ἐστιν οἷον σπόγγος, κηρός, σάρξ.
ἀπίεστα δὲ τὰ μὴ πεφυκότα συνιέναι ὥσει εἰς
10 τοὺς ἑαυτῶν πόρους διὰ τὸ ἢ μὴ ἔχειν ἢ σκληρο-
τέρων ἔχειν πλήρεις· ὁ γὰρ σίδηρος ἀπίεστος καὶ
λίθος καὶ ὕδωρ καὶ πᾶν ὑγρόν.

Ἑλκτὰ δ' ἐστὶν ὅσων δυνατὸν εἰς τὸ πλάγιον
μεθίστασθαι τὸ ἐπίπεδον· τὸ γὰρ ἕλκεσθαί ἐστι τὸ
ἐπὶ τὸ κινοῦν μεθίστασθαι τὸ ἐπίπεδον συνεχὲς ὄν.
ἔστιν δὲ τὰ μὲν ἑλκτά, οἷον θρίξ, ἱμάς, νεῦρον,
15 σταίς, ἰξός, τὰ δ' ἄνελκτα, οἷον ὕδωρ καὶ λίθος. τὰ
μὲν οὖν ταὐτά ἐστιν ἑλκτὰ καὶ πιεστά, οἷον ἔριον,
τὰ δ' οὐ ταὐτά, οἷον φλέγμα πιεστὸν μὲν οὐκ
ἔστιν, ἑλκτὸν δέ, καὶ ὁ σπόγγος πιεστὸν μέν, οὐχ
ἑλκτὸν δέ.

of retaining an impression, like wool or sponge, are non-plastic but can be squeezed. Now things that can be squeezed are those that can contract into themselves on pressure, their surface sinking in without being broken and without displacement of one part by another such as occurs in water. Pressure is action by a moving force which remains in contact with its object: impact is action by impulse. And things can be squeezed which have pores empty of their own material and which can therefore contract under pressure into the empty space within them, that is, into their own pores; for sometimes the pores into which they contract are not empty, as, for instance, in a wet sponge, whose pores are full, but in that case the material filling the pores must be softer than the body which is to contract on itself. Sponges, wax and flesh can therefore all be squeezed: things that cannot be squeezed are those which are not constituted to contract on pressure into their own pores either because they have none or because they are full of a material harder than themselves. So iron cannot be squeezed, or stone, or water, or any liquid (10) Squeezability.

Ductile are things whose surface will extend in the same plane, for to be drawn out is to have the surface extended in the direction of the motive force without breaking. And some things are ductile, like hair, leather, sinew, dough and birdlime, some are not, like water and stone. And some things are both ductile and squeezable, like wool, some are not, like phlegm, which is not squeezable but is ductile, or sponge, which is squeezable but is not ductile. (11) Ductility.

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[1] ἐνίοτε . . . συνέρχεται secl. Fobes: om. J 𝔐 $\mathfrak{B}_1$ H.

[2] αὐτό O.T.: αὐτό E_{corr} 𝔚 N: αὐτό $\mathfrak{B}_{rec}$: ἑαυτά J_1 $\mathfrak{B}_1$ H: ἑαυτό J_{rec}: αὐτά Fobes.

386 b

Ἔστιν δὲ καὶ τὰ μὲν ἐλατά, οἷον χαλκός, τὰ δ' ἀνήλατα, οἷον λίθος καὶ ξύλον. ἔστιν δ' ἐλατὰ μὲν ὅσα τῇ αὐτῇ πληγῇ δύναται ἅμα καὶ εἰς πλάτος καὶ εἰς βάθος τὸ ἐπίπεδον μεθίστασθαι κατὰ μέρος, ἀνήλατα δὲ ὅσα ἀδύνατα. ἔστιν δὲ τὰ μὲν ἐλατὰ ἅπαντα καὶ θλαστά, τὰ δὲ θλαστὰ οὐ πάντα ἐλατά, οἷον ξύλον· ὡς μέντοι ἐπίπαν εἰπεῖν, ἀντιστρέφει. τῶν δὲ πιεστῶν τὰ μὲν ἐλατὰ τὰ δ' οὔ, κηρὸς μὲν καὶ πηλὸς ἐλατά, ἔριον δ' οὔ [οὐδ' ὕδωρ].[1]

Ἔστιν δὲ καὶ τὰ μὲν σχιστά, οἷον ξύλον, τὰ δὲ ἄσχιστα, οἷον κέραμος. ἔστιν δὲ σχιστὸν τὸ δυνάμενον διαιρεῖσθαι ἐπὶ πλέον ἢ τὸ διαιροῦν διαιρεῖ· σχίζεται γάρ, ὅταν ἐπὶ πλέον διαιρῆται ἢ τὸ διαιροῦν διαιρεῖ, καὶ προηγεῖται ἡ διαίρεσις· ἐν δὲ τῇ τμήσει οὐκ ἔστιν τοῦτο. ἄσχιστα δὲ ὅσα μὴ δύνανται τοῦτο πάσχειν. ἔστιν δὲ οὔτε μαλακὸν οὐδὲν σχιστόν (λέγω δὲ τῶν ἁπλῶς μαλακῶν καὶ μὴ πρὸς ἄλληλα· οὕτω μὲν γὰρ καὶ σίδηρος ἔσται
387 a μαλακός) οὔτε τὰ σκληρὰ πάντα, ἀλλ' ὅσα μήτε ὑγρά ἐστιν μήτε θλαστὰ μήτε θραυστά· τοιαῦτα δ' ἐστὶν ὅσα κατὰ μῆκος ἔχει τοὺς πόρους, καθ' οὓς προσφύεται ἀλλήλοις, ἀλλὰ μὴ κατὰ πλάτος.

Τμητὰ δ' ἐστὶν τῶν συνεστώτων σκληρῶν ἢ μαλακῶν ὅσα δύναται μήτ' ἐξ ἀνάγκης προηγεῖσθαι τῆς διαιρέσεως μήτε θραύεσθαι διαιρούμενα· ὅσα δὲ μὴ ὑγρὰ ᾖ,[2] τὰ τοιαῦτα ἄτμητα. ἔνια δ' ἐστὶν ταὐτὰ καὶ τμητὰ καὶ σχιστά, οἷον ξύλον· ἀλλ' ὡς ἐπὶ τὸ πολὺ σχιστὸν μὲν κατὰ τὸ μῆκος, τμητὸν δὲ κατὰ τὸ πλάτος· ἐπεὶ γὰρ διαιρεῖται ἕκαστον εἰς πολλά, ᾗ μὲν μήκη πολλὰ τὸ ἕν, σχιστὸν ταύτῃ, ᾗ δὲ πλάτη πολλὰ τὸ ἕν, τμητὸν ταύτῃ.

[1] del. Thurot Fobes.

Similarly some things are malleable, like bronze, some are not, like stone and wood. And things are malleable part of whose surface will yield and extend simultaneously under the same blow, while things with which this is impossible are non-malleable. All malleable things will take an impression, but not all things that will take an impression are malleable, wood for example: but, generally speaking, the two terms are convertible. Of things that can be squeezed some are malleable, some are not, wax and mud being malleable, wool not. (12) Malleability.

Some things are fissile, like wood, some non-fissile, like earthenware. Fissile are things in which division can continue beyond the dividing agent: for a thing is split when it is divided to a point beyond that reached by the dividing agent and the division runs in advance of it, whereas in cutting this is not so. Non-fissile are things which have not this property. Nothing soft is fissile (I mean absolutely and not relatively soft, for iron can be relatively soft), nor are all hard things, but only things which are not liquid or impressible or fragmentable, that is to say, in which the pores along which they cohere run lengthwise and not crosswise. (13) Fissility

Cuttable are hard or soft solid bodies which when divided do not necessarily split in advance of the tool or break into fragments; and everything that is not moist is uncuttable. Some things, like wood, can both be cut and split, but, generally speaking, things split lengthwise and cut crosswise; for things are divisible into many parts, and if the parts making up the unit run lengthwise it is fissile, if they run crosswise it is cuttable. (14) Cuttable and uncuttable

[2] ἢ ὑγρὰ ἢ Bekker O.T.

387 a

Γλίσχρον δ' ἐστὶν ὅταν ἑλκτὸν ᾖ ὑγρὸν ὂν ἢ μαλακόν. τοιοῦτον δὲ γίγνεται τῇ ἐπαλλάξει ὅσα ὥσπερ αἱ ἁλύσεις σύγκεινται τῶν σωμάτων· ταῦτα γὰρ ἐπὶ πολὺ δύναται ἐκτείνεσθαι καὶ συνιέναι. ὅσα δὲ μὴ τοιαῦτα, ψαθυρά.

Πιλητὰ δ' ὅσα τῶν πιεστῶν μόνιμον ἔχει τὴν πίεσιν, ἀπίλητα δὲ ὅσα ἢ ὅλως ἀπίεστα ἢ μὴ μόνιμον ἔχει τὴν πίεσιν.

Καὶ τὰ μὲν καυστά ἐστιν τὰ δὲ ἄκαυστα, οἷον ξύλον μὲν καυστὸν καὶ ἔριον καὶ ὀστοῦν, λίθος δὲ καὶ κρύσταλλος ἄκαυστον. ἔστιν δὲ καυστὰ ὅσα ἔχει πόρους δεκτικοὺς πυρὸς καὶ ὑγρότητα ἐν τοῖς κατ' εὐθυωρίαν πόροις ἀσθενεστέραν πυρός. ὅσα δὲ μὴ ἔχει ἢ ἰσχυροτέραν, οἷον κρύσταλλος καὶ τὰ σφόδρα χλωρά, ἄκαυστα.

Θυμιατὰ δ' ἐστὶ τῶν σωμάτων ὅσα ὑγρότητα ἔχει μέν, οὕτω δ' ἔχει ὥστε μὴ ἐξατμίζειν πυρουμένων χωρίς· ἔστιν γὰρ ἀτμὶς ἡ ὑπὸ θερμοῦ καυστικοῦ εἰς ἀέρα καὶ πνεῦμα ἔκκρισις ἐξ ὑγροῦ διαντική. τὰ δὲ θυμιάματα[1] χρόνῳ εἰς ἀέρα ἐκκρίνεται, καὶ τὰ μὲν ἀφανιζόμενα ξηρά, τὰ δὲ γῆ γίγνεται. διαφέρει δ' αὕτη ἡ ἔκκρισις, ὅτι οὔτε διαίνει οὔτε πνεῦμα γίγνεται. ἔστιν δὲ πνεῦμα ῥύσις συνεχὴς ἀέρος ἐπὶ μῆκος· θυμίασις δ' ἐστὶν ἡ ὑπὸ θερμοῦ καυστικοῦ κοινὴ ἔκκρισις ξηροῦ καὶ ὑγροῦ ἀθρόως·

A thing is viscous when it is ductile as well as being liquid or soft. And this characteristic belongs to all bodies with interlocking parts, whose composition is like that of chains; for they admit of considerable extension and contraction. Bodies which have not this characteristic are friable. (15) Viscous or friable

Compressible bodies are those which can be squeezed and retain the shape into which they have been squeezed: incompressible are either those which cannot be squeezed at all or those which when squeezed do not retain the shape into which they have been squeezed. (16) Compressibility

Some things are combustible, some incombustible; for example, wood is combustible and wool and bone, while stone and ice are incombustible. All things are combustible which have pores which fire can penetrate and which contain in their longitudinal pores too little moisture to overcome the fire. But things which have no pores or contain enough moisture to master the fire are incombustible, as, for example, ice and very green matter. (17) Combustibility

Fumes are given off by bodies which contain moisture, but in such a way that it does not evaporate separately when they are exposed to fire. For vapour is a moist exhalation into air and wind, given off by moisture in a body when exposed to burning heat; but fumes can be exhaled into the air in course of time, and either dry up and vanish or turn into earth, being a different form of exhalation which is not moist and does not become wind. (Wind is a continuous current of air in a given direction.) But fuming is the exhalation of dry and moist together due to burning heat: hence it does not wet, but

[1] *θυμιάματα* E_1: *θυμιατὰ* Fobes.

387 a διόπερ οὐ διαίνει, ἀλλὰ χρωματίζει μᾶλλον. ἔστι
387 b δ' ἡ μὲν ξυλώδους σώματος θυμίασις καπνός. λέγω γὰρ καὶ ὀστᾶ καὶ τρίχας καὶ πᾶν τὸ τοιοῦτον ἐν ταὐτῷ· οὐ γὰρ κεῖται ὄνομα κοινόν, ἀλλὰ κατ' ἀναλογίαν ὅμως ἐν ταὐτῷ πάντ' ἐστίν, ὥσπερ καὶ Ἐμπεδοκλῆς φησιν

5 ταὐτὰ τρίχες καὶ φύλλα καὶ οἰωνῶν πτερὰ πυκνὰ καὶ λοπίδες γίγνονται ἐπὶ στιβαροῖσι μέλεσσιν.

ἡ δὲ πίονος θυμίασις λιγνύς, ἡ δὲ λιπαροῦ κνῖσα. διὰ τοῦτο τὸ ἔλαιον οὐχ ἕψεται οὐδὲ παχύνεται, ὅτι θυμιατόν ἐστιν ἀλλ' οὐκ ἀτμιστόν· ὕδωρ δ' οὐ θυμιατὸν ἀλλ' ἀτμιστόν. οἶνος δ' ὁ μὲν γλυκὺς θυμιᾶ-
10 ται. πίων γάρ, καὶ ταὐτὰ ποιεῖ τῷ ἐλαίῳ· οὔτε γὰρ ὑπὸ ψύχους πήγνυται, καίεταί τε. ἔστιν δὲ ὀνόματι οἶνος, ἔργῳ δ' οὐκ ἔστιν· οὐ γὰρ οἰνώδης ὁ χυμός· διὸ οὐ μεθύσκει, ὁ τυχὼν δ' οἶνος (μικρὰν δ' ἔχει θυμίασιν· διὸ ἀνίησιν φλόγα).

Καυστὰ δὲ δοκεῖ εἶναι ὅσα εἰς τέφραν διαλύεται
15 τῶν σωμάτων. πάσχει δὲ τοῦτο πάντα ὅσα πέπηγεν ἢ ὑπὸ θερμοῦ ἢ ὑπ' ἀμφοῖν, ψυχροῦ καὶ θερμοῦ· ταῦτα γὰρ φαίνεται κρατούμενα ὑπὸ τοῦ πυρός· ἥκιστα δὲ τῶν λίθων ἡ σφραγίς, ὁ καλούμενος ἄνθραξ. τῶν δὲ καυστῶν τὰ μὲν φλογιστά ἐστιν τὰ δ' ἀφλόγιστα· τούτων δ' ἔνια ἀνθρακευτά.
20 φλογιστὰ μὲν οὖν ὅσα φλόγα δύναται παρέχεσθαι· ὅσα δὲ ἀδύνατα, ἀφλόγιστα. ἔστι δὲ φλογιστὰ ὅσα

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[a] The text and meaning of 387 a 24 ἔστιν γάρ . . . 31-32 χρωματίζει μᾶλλον is uncertain. I follow Fobes's text, with the substitution of *θυμιάματα* for *θυμιατά* in l. 26, and take the argument to be as follows: Fumes are given off by bodies containing moisture when the moisture does not evaporate separately (*θυμιατά*, *θυμιάματα*, *θυμίασις* contrasted with

rather discolours things.[a] The fumes of woody material are smoke. And I include in this designation bones and hair and all such things: for there is no common term for them but they are analogous and so classified together. So Empedocles says: "The same are hair and leaves and birds' thick feathers and scales upon strong limbs." [b] The fumes of fat are sooty, of oily substances steamy. The reason why oil does not boil or thicken is that it gives off fumes but does not evaporate: water, on the other hand, evaporates but does not fume Sweet wine fumes, being fat and behaving in the same way as oil, for cold does not solidify it and it will burn. And though called wine, it has not the effect of wine, for it does not taste like wine and does not intoxicate like ordinary wine. It gives off few fumes and so is inflammable.

Combustible bodies are those which dissolve into ash. And all bodies do this which have been solidified by heat or by both heat and cold, for we find them mastered by fire. Least affected by fire is the gem commonly called carbuncle. Of combustible [c] bodies some are inflammable, some are not, and some of the former can be carbonized. Inflammable bodies are those which can produce flame; those which cannot are uninflammable. Bodies which are not moist but

ἀτμίς, ἀτμίζειν: *cf.* the contrast between θυμιατόν and ἀτμιστόν in b 7-8). Evaporation (ἀτμίς) is also a moist exhalation, but fuming differs from it in that evaporation takes moisture off and is moist, fuming takes moist and dry off together and does not moisten but discolours. *Cf.* also the moist and dry exhalations of Book II. ch. 4.

[b] Diels 31 B 82.

[c] Aristotle returns to combustibility ((17) above) and considers certain forms it takes (*e.g.* inflammability) and its relation to fuming.

387 b μὴ ὑγρὰ ὄντα θυμιατά ἐστιν· πίττα δὲ ἢ ἔλαιον ἢ κηρὸς μᾶλλον μετ' ἄλλων ἢ καθ' αὑτὰ φλογιστά· μάλιστα δ' ὅσα καπνὸν ἀνίησιν. ἀνθρακευτὰ δ' ὅσα τῶν τοιούτων γῆς πλέον ἔχει ἢ καπνοῦ. ἔτι δ' ἔνια τηκτὰ ὄντα οὐ φλογιστά ἐστιν, οἷον χαλκός, καὶ φλογιστὰ οὐ τηκτά, οἷον ξύλον, τὰ δ' ἄμφω, οἷον λιβανωτός. αἴτιον δ' ὅτι τὰ μὲν ξύλα ἀθρόον ἔχει τὸ ὑγρόν, καὶ δι' ὅλου συνεχές ἐστιν, ὥστε διακάεσθαι, ὁ δὲ χαλκὸς παρ' ἕκαστον μὲν μέρος, οὐ συνεχὲς δέ, καὶ ἔλαττον ἢ ὥστε φλόγα ποιῆσαι· ὁ δὲ λιβανωτὸς τῇ μὲν οὕτως τῇ δ' ἐκείνως ἔχει. φλογιστὰ δ' ἐστὶν τῶν θυμιατῶν ὅσα μὴ τηκτά ἐστιν διὰ τὸ μᾶλλον εἶναι γῆς. τὸ ξηρὸν γὰρ ἔχει
388 a κοινὸν τῷ πυρί· τοῦτ' οὖν θερμὸν ἂν γένηται τὸ ξηρόν, πῦρ γίγνεται. διὰ τοῦτο ἡ φλὸξ πνεῦμα ἢ καπνὸς καόμενός ἐστιν.[1] ξύλων μὲν οὖν ἡ θυμίασις καπνός, κηροῦ δὲ καὶ λιβανωτοῦ καὶ τῶν τοιούτων καὶ πίττης, καὶ ὅσα ἔχει πίτταν ἢ τοιαῦτα, λιγνύς, ἐλαίου δὲ καὶ ὅσα ἐλαιώδη, κνῖσα, καὶ ὅσα ἥκιστα καίεται μόνα, ὅτι ὀλίγον ξηροῦ ἔχει, ἡ δὲ μετάβασις διὰ τούτου, μετὰ δ' ἑτέρου τάχιστα· τοῦτο γάρ ἐστιν τὸ πῖον, ξηρὸν λιπαρόν. τὰ μὲν οὖν ἐκθυμιώμενα [τῶν ὑγρῶν][2] ὑγροῦ μᾶλλον, ὡς ἔλαιον καὶ πίττα, τὰ δὲ καόμενα ξηροῦ.

[1] τὸ ξηρὸν l. 32 . . . ἐστιν interclusionem distinxit Thurot, habet Fobes.
[2] seclusi : del. O.T.

[a] *Cf.* 387 b 22.

contain fumes are inflammable. Pitch, oil and wax are more inflammable when mixed with other things than by themselves. Most inflammable of all are things which produce smoke. All materials of this sort which contain more earth than smoke can be carbonized. Some bodies that can be melted are not inflammable, like bronze, and some inflammable bodies will not melt, like wood, while some bodies melt and burn like frankincense. The reason is that the moisture in wood is concentrated and distributed evenly so that it can be burnt out, while in bronze it is dispersed into each part and not continuous and is not sufficient in quantity to give rise to flame, whereas in frankincense both conditions obtain. Bodies which fume and do not melt because earth preponderates in them are inflammable. For in their dryness they have a factor in common with fire, and when this dryness becomes hot, fire is produced: flame, therefore, is burning wind or smoke. The fumes, then, of wood are smoke, the fumes of wax and frankincense and the like, of pitch and materials containing pitch or similar constituents, are sooty, and the fumes of oil and oily substances are steamy, as are also those of substances which do not burn readily by themselves, having little dryness (by which the transition to fire is effected) but do burn readily with other things [a]; for fat is a combination of dry and oily. And bodies which give off fumes are predominantly moist (*e.g.* oil and pitch), bodies which burn are predominantly dry.

ARISTOTLE

CHAPTER X

ARGUMENT

Dry and moist in homoeomerous bodies *Having thus described the properties which distinguish homoeomerous bodies, we must determine in what proportion dry and moist,* i.e. *earth and water, their material cause, are present in them* (388 a 10-25). *All bodies are either liquid or solid, and there*

388 a 10 Τούτοις δὲ τοῖς παθήμασιν καὶ ταύταις ταῖς διαφοραῖς τὰ ὁμοιομερῆ τῶν σωμάτων, ὥσπερ εἴρηται, διαφέρει ἀλλήλων κατὰ τὴν ἁφήν, καὶ ἔτι χυμοῖς καὶ ὀσμαῖς καὶ χρώμασιν· λέγω δ' ὁμοιομερῆ οἷον τά τε μεταλλευόμενα—χαλκόν, χρυσόν, ἄργυρον, 15 καττίτερον, σίδηρον, λίθον, καὶ τἆλλα τὰ τοιαῦτα, καὶ ὅσα ἐκ τούτων γίγνεται ἐκκρινόμενα—καὶ τὰ ἐν τοῖς ζῴοις καὶ φυτοῖς, οἷον σάρκες, ὀστᾶ, νεῦρον, δέρμα, σπλάγχνον, τρίχες, ἶνες, φλέβες, ἐξ ὧν ἤδη συνέστηκε τὰ ἀνομοιομερῆ, οἷον πρόσωπον, χείρ, πούς, καὶ τἆλλα τὰ τοιαῦτα, καὶ ἐν φυτοῖς ξύλον, 20 φλοιός, φύλλον, ῥίζα, καὶ ὅσα τοιαῦτα. ἐπεὶ δὲ ταῦτα μὲν ὑπ' ἄλλης αἰτίας συνέστηκεν, ἐξ ὧν δὲ ταῦτα ὕλη μὲν τὸ ξηρὸν καὶ ὑγρόν, ὥστε ὕδωρ καὶ γῆ (ταῦτα γὰρ προφανεστάτην ἔχει τὴν δύναμιν ἑκάτερον ἑκατέρου), τὰ δὲ ποιοῦντα τὸ θερμὸν καὶ 25 ψυχρόν (ταῦτα γὰρ συνίστησιν καὶ πήγνυσιν ἐξ

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[a] 385 a 8.

[b] If we take ἐν φυτοῖς . . . τοιαῦτα (ll. 19-20) as parallel to the whole clause καὶ τὰ ἐν τοῖς ζῴοις καὶ φυτοῖς . . . τἆλλα τὰ τοιαῦτα (ll. 16-19) with the O.T., wood, bark, etc., are given as examples of homoeomerous bodies. If we take them as part of the clause beginning ἐξ ὧν (l. 18) they are examples of anhomoeomerous bodies. In fact, wood and bark are

CHAPTER X

ARGUMENT (*continued*)

are various principles by which the proportion can be determined for liquids and solids (388 a 25—389 a 7). *The proportions for homoeomerous bodies are determined and these bodies classified accordingly* (389 a 7-23).

The homoeomerous bodies what proportions of earth and water do they contain ?

THESE are the different characteristics which, as we have said,[a] distinguish homoeomerous bodies from each other to touch ; and they are further distinguished by taste, smell and colour. By homoeomerous bodies I mean, for example, metallic substances (*e.g.* bronze, gold, silver, tin, iron, stone and similar materials and their by-products) and animal and vegetable tissues (*e.g.* flesh, bone, sinew, skin, intestine, hair, fibre, veins) from which in turn the anhomoeomerous bodies, face, hand, foot and the like, are composed ; in plants, examples are wood, bark, leaf, root and the like.[b] The non-homoeomerous [c] bodies owe their constitution to another cause ; the *material* cause of the homoeomerous bodies which make them up is dry and moist, that is, water and earth, which display most clearly these two characteristics ; their *efficient* cause is heat and cold, which produce concrete

clearly homoeomerous, leaf and root pretty clearly not homoeomerous (*De An.* 412 b 2-3 : though at 389 a 13 below *φύλλα* are listed among homoeomerous substances). I suggest that Aristotle is writing loosely and that the phrase is added on to the end of the sentence to give examples from plants parallel to those given for animals, and that examples of both kinds of substance are therefore included.

[c] *ταῦτα* (l. 20) must refer to the *last-named*, *i.e.* anhomoeomerous bodies (Alex. 219. 20), and not to the homoeomerous (O.T., Ideler) ; *ἐξ ὧν . . . ὕλη* (l 21), if expanded, would be *ἐκείνων δέ, ἐξ ὧν ταῦτα συνέστηκεν, ὕλη* (Alex. 219. 21-22).

388 a ἐκείνων), λάβωμεν τῶν ὁμοιομερῶν ποῖα γῆς εἴδη καὶ ποῖα ὕδατος καὶ ποῖα κοινά.

Ἔστι δὴ τῶν σωμάτων τῶν δεδημιουργημένων τὰ μὲν ὑγρά, τὰ δὲ μαλακά, τὰ δὲ σκληρά· τούτων δὲ ὁπόσα σκληρὰ ἢ μαλακὰ ⟨ὅτι⟩[1] πήξει ἐστίν, εἴρηται πρότερον.

30 Τῶν μὲν οὖν ὑγρῶν ὅσα μὲν ἐξατμίζεται, ὕδατος, ὅσα δὲ μή, ἢ γῆς ἢ κοινὰ γῆς καὶ ὕδατος, οἷον γάλα, ἢ γῆς καὶ ἀέρος, οἷον ξύλον,[2] ἢ ὕδατος καὶ ἀέρος, οἷον ἔλαιον. καὶ ὅσα μὲν ὑπὸ θερμοῦ παχύνεται, κοινά (ἀπορήσειε δ' ἄν τις περὶ οἴνου τῶν ὑγρῶν·
388 b τοῦτο γὰρ καὶ ἐξατμισθείη ἄν, καὶ παχύνεται ὥσπερ ὁ νέος· αἴτιον δ' ὅτι οὔτε ἐν ἑνὶ εἴδει λέγεται ὁ οἶνος, καὶ ὅτι ἄλλος ἄλλως· ὁ γὰρ νέος μᾶλλον γῆς ἢ ὁ παλαιός· διὸ καὶ παχύνεται τῷ θερμῷ μάλιστα καὶ
5 πήγνυται ἧττον ὑπὸ τοῦ ψυχροῦ· ἔχει γὰρ καὶ θερμὸν πολὺ καὶ γῆς, ὥσπερ ὁ ἐν Ἀρκαδίᾳ οὕτως ἀποξηραίνεται ὑπὲρ τοῦ καπνοῦ ἐν τοῖς ἀσκοῖς ὥστε ξυόμενος πίνεσθαι· εἰ δὴ ἅπας ἰλὺν ἔχει, οὕτως ἑκατέρου ἐστίν, ἢ γῆς ἢ ὕδατος, ὡς ταύτης ἔχει πλῆθος)· ὅσα δὲ ὑπὸ ψυχροῦ παχύνεται, γῆς· ὅσα
10 δ' ὑπ' ἀμφοῖν, κοινὰ πλειόνων, οἷον ἔλαιον καὶ μέλι καὶ ὁ γλυκὺς οἶνος.

Τῶν δὲ συνεστώτων ὅσα μὲν πέπηγεν ὑπὸ ψυχροῦ, ὕδατος, οἷον κρύσταλλος, χιών, χάλαζα, πάχνη· ὅσα δ' ὑπὸ θερμοῦ, γῆς, οἷον κέραμος, τυρός,

[1] ὅτι ci. O.T. [2] μέλι ci. Vicomercatus.

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[a] 382 a 25.
[b] Idelei accepts Vicomercato's conjecture "honey."
[c] *Cf.* 380 b 32, 384 a 5, 387 b 9.

homoeomerous bodies out of water and earth. Let us therefore consider which of the homoeomerous bodies are composed of earth, which of water, and which of both

Bodies which are finished products are either liquid or soft or hard: and those which are soft or hard are, as has been explained, the result of solidification.[a] Bodies classified as

Liquids which evaporate are made of water; those which do not are made of earth or are a mixture of earth and water, like milk, or of earth and air, like wood,[b] or of water and air, like oil. Liquids whose density heat increases are a mixture. (Among the liquids, wine [c] presents a difficulty, for it evaporates and also thickens, as new wine does. The reason is that there is more than one kind of liquid called wine and that different kinds behave differently. For new wine contains more earth than old, and so thickens most under the influence of heat, but solidifies less under the influence of cold; for it contains considerable quantities of heat and earth, as in Arcadia where the smoke dries it up in the skins to such an extent that it must be scraped off before it is drunk. If, then, all wine has some sediment, whether earth or water predominates in it will depend on the amount of sediment present) Liquids whose density cold increases are earthy: bodies whose density is increased both by heat and cold are compounded of more than one element, like oil and honey and sweet wine. (1) Liquid

(*a*) Solids which solidify as a result of cold are composed of water, for example, ice, snow, hail and frost; (*b*) those which solidify as a result of heat are composed of earth, for example, earthenware, cheese, (2) Solid

388 b νίτρον, ἅλες· ὅσα δ' ὑπ' ἀμφοῖν (τοιαῦτα δ' ἐστὶν ὅσα ψύξει· ταῦτα δ' ἐστὶν ὅσα ἀμφοῖν στερήσει, καὶ θερμοῦ καὶ ὑγροῦ συνεξιόντος τῷ θερμῷ· οἱ μὲν γὰρ ἅλες ὑγροῦ μόνου στερήσει πήγνυνται, καὶ ὅσα εἰλικρινῆ γῆς, ὁ δὲ κρύσταλλος θερμοῦ μόνου), ταῦτα δ' ἀμφοῖν. διὸ καὶ ὑπ' ἀμφοῖν καὶ εἶχεν ἄμφω. ὅσων μὲν οὖν ἅπαν ἐξικμάσθη, οἷον κέραμος ἢ ἤλεκτρον (καὶ γὰρ τὸ ἤλεκτρον, καὶ ὅσα λέγεται ὡς δάκρυα, ψύξει ἐστίν, οἷον σμύρνα, λιβανωτός, κόμμι· καὶ τὸ ἤλεκτρον δὲ τούτου τοῦ γένους ἔοικεν, καὶ πήγνυται· ἐμπεριειλημμένα γοῦν ζῷα ἐν αὐτῷ φαίνεται· ὑπὸ δὲ τοῦ ποταμοῦ τὸ θερμὸν ἐξιὸν ὥσπερ τοῦ ἑψομένου μέλιτος, ὅταν εἰς ὕδωρ ἀφεθῇ, ἐξατμίζει τὸ ὑγρόν), ταῦτα πάντα γῆς. καὶ τὰ μὲν ἄτηκτα καὶ ἀμάλακτα, οἷον τὸ ἤλεκτρον καὶ λίθοι ἔνιοι, ὥσπερ οἱ πῶροι οἱ ἐν τοῖς σπηλαίοις· καὶ γὰρ οὗτοι ὁμοίως γίγνονται τούτοις, καὶ οὐχ ὡς ὑπὸ πυρὸς ἀλλ' ὡς ὑπὸ τοῦ ψυχροῦ διεξιόντος τοῦ θερμοῦ συνεξέρχεται τὸ ὑγρὸν ὑπὸ τοῦ ἐξ αὐτοῦ ἐξιόντος θερμοῦ· ἐν δὲ τοῖς ἑτέροις ὑπὸ τοῦ ἔξωθεν πυρός. ὅσα δὲ μὴ ὅλα, γῆς μέν ἐστι μᾶλλον, μαλακτὰ δέ, οἷον σίδηρος καὶ κέρας. (λιβανωτοὶ δὲ καὶ τὰ τοιαῦτα παραπλησίως τοῖς ξύλοις ἀτμίζει.)[1] ἐπεὶ οὖν τηκτά γε θετέον καὶ ὅσα τήκεται ὑπὸ πυρός, ταῦτ' ἐστὶν ὑδατωδέστερα, ἔνια
389 a δὲ καὶ κοινά, οἷον κηρός· ὅσα δὲ ὑπὸ ὕδατος, ταῦτα

[1] λιβανωτοὶ . . . ἀτμίζει fortasse post κόμμι l. 20 supra traiciendum.

soda, salt ; (*c*) those which solidify as a result of both [a] are composed of both and so are solidified by both causes and contain both constituents. (Into this last category fall things solidified by cooling, that is by deprivation both of heat and moisture, the moisture escaping with the heat : for salt and things composed purely of earth solidify when deprived of moisture only, while ice, on the other hand, does so when deprived of heat only) (*d*) Solids from which all moisture has been evaporated, as *e.g.* earthenware or amber, are composed of earth. (For both amber and substances called tears are formed by cooling, for example myrrh, frankincense and gum : and amber appears to belong to this class, as the insects trapped in it show that it has formed by solidification. The heat expelled by the cold of the river evaporates the moisture in it, as it does in boiled honey when it is dropped into water.) And some of these solids cannot be melted or softened, like amber and some kinds of stone, for example stalactites in caves ; for these too are formed in the same way, being solidified not by fire but because their heat is driven out by cold and their moisture accompanies the heat when it retires In the others [b] the cause is external fire. (*e*) Solids from which the moisture has not wholly evaporated contain a preponderance of earth but can be softened by heat like iron and horn. (Frankincense and similar bodies give off vapour rather as wood does.) (*f*) Finally, since things that are melted by fire must be included in the class of things that melt, they will in general be composed largely of water, though some, like wax, will be composed of both water and earth on the other hand, things that

[a] *Cf.* 383 a 13. [b] *i.e.* that can be melted, *e.g.* salt.

389 a δὲ γῆς· ὅσα δὲ μηδ' ὑφ' ἑτέρου, ταῦτα ἢ γῆς ἢ ἀμφοῖν.

Εἰ οὖν ἅπαντα μὲν ἢ ὑγρὰ ἢ πεπηγότα, τούτων δὲ τὰ ἐν τοῖς εἰρημένοις πάθεσιν, καὶ οὐκ ἔστιν μεταξύ, ἅπαντ' ἂν εἴη εἰρημένα οἷς διαγνωσόμεθα πότερον γῆς ἢ ὕδατος ἢ πλειόνων κοινόν, καὶ πότερον ὑπὸ πυρὸς συνέστηκεν ἢ ψυχροῦ ἢ ἀμφοῖν.

Χρυσὸς μὲν δὴ καὶ ἄργυρος καὶ χαλκὸς καὶ καττίτερος καὶ μόλυβδος καὶ ὕαλος καὶ λίθοι πολλοὶ ἀνώνυμοι ὕδατος· πάντα γὰρ τήκεται ταῦτα θερμῷ. ἔτι οἶνοι ἔνιοι καὶ οὖρον καὶ ὄξος καὶ κονία καὶ ὀρὸς καὶ ἰχὼρ ὕδατος· πάντα γὰρ πήγνυται ψυχρῷ. σίδηρος δὲ καὶ κέρας καὶ ὄνυξ καὶ ὀστοῦν καὶ νεῦρον καὶ ξύλον καὶ τρίχες καὶ φύλλα καὶ φλοιὸς γῆς μᾶλλον· ἔτι ἤλεκτρον, σμύρνα, λίβανος, καὶ πάντα τὰ δάκρυα λεγόμενα, καὶ πῶρος, καὶ οἱ καρποί, οἷον τὰ χεδροπά, καὶ σῖτος (τὰ τοιαῦτα γὰρ τὰ μὲν σφόδρα, τὰ δὲ ἧττον μὲν τούτων, ὅμως δὲ γῆς· τὰ μὲν γὰρ μαλακτά, τὰ δὲ θυμιατὰ καὶ ψύξει γεγενημένα)· ἔτι νίτρον, ἅλες, λίθων γένη, ὅσα μήτε ψύξει μήτε τηκτά. αἷμα δὲ καὶ γονὴ κοινὰ γῆς καὶ ὕδατος καὶ ἀέρος, τὸ μὲν ἔχον αἷμα ἶνας μᾶλλον γῆς (διὸ ψύχει πήγνυται καὶ ὑγρῷ τήκεται), τὰ δὲ μὴ ἔχοντα ἶνας ὕδατος (διὸ καὶ οὐ πήγνυται). γονὴ δὲ πήγνυται ψύξει ἐξιόντος τοῦ ὑγροῦ μετὰ τοῦ θερμοῦ.

are melted by water will be composed of earth, and things melted by neither of earth or both.

If, then, all things are either liquid or solid, and if the things qualified by the characteristics we have described are covered by this alternative, and there is no intermediate possibility, it follows that we have enumerated all the criteria whereby we can distinguish whether a thing is composed of earth or of water or of more than one element, and whether it is formed by fire, by cold or by both.

The following are therefore composed of water: gold, silver, bronze, tin, lead, glass and many kinds of stone which have no name, for all of these are melted by heat; in addition, some wines, urine, vinegar, lye, whey and serum, for all of these are solidified by cold. Earth preponderates in the following: iron, horn, nail, bone, sinew, wood, hair, leaves and bark, besides amber, myrrh, frankincense, the drop-like substances, stalactites, and produce such as vegetables and corn (in these the proportion of earth varies but all are earthy, for some can be softened by fire, others give off fumes and are produced by cooling); in addition there are soda, salt, and those kinds of stone that are neither formed by cooling nor able to be melted. Blood and semen, on the other hand, are composed of earth, water and air, blood which contains fibres having a preponderance of earth (and so being solidified by cooling and melted by liquid), blood which contains no fibres having a preponderance of water (and so not solidifying); semen is solidified by cooling when its moisture leaves it at the same time as its heat.

The proportions for the homoeomerous bodies determined

CHAPTER XI

ARGUMENT

Hot and cold in solids and liquids. (1) *Bodies composed of water are, generally speaking, cold,* (2) *bodies composed of earth hot, though bodies composed of either alone tend to be cold.* (3) *Bodies composed of more than one element tend to*

389 a 24 Ποῖα δὲ θερμὰ ἢ ψυχρὰ τῶν πεπηγότων ἢ τῶν
25 ὑγρῶν, ἐκ τῶν εἰρημένων δεῖ μεταδιώκειν. ὅσα
μὲν οὖν ὕδατος, ὡς ἐπὶ τὸ πολὺ ψυχρά, ἐὰν μὴ
ἀλλοτρίαν ἔχῃ θερμότητα, οἷον κονία, οὖρον, οἶνος·
ὅσα δὲ γῆς, ὡς ἐπὶ τὸ πολὺ θερμὰ διὰ τὴν τοῦ
θερμοῦ δημιουργίαν, οἷον τίτανος καὶ τέφρα.

Δεῖ δὲ λαβεῖν τὴν ὕλην ψυχρότητά τινα εἶναι·
30 ἐπεὶ γὰρ τὸ ξηρὸν καὶ τὸ ὑγρὸν ὕλη (ταῦτα γὰρ
παθητικά), τούτων δὲ σώματα μάλιστα γῆ καὶ
ὕδωρ ἐστίν (ταῦτα γὰρ ψυχρότητι ὥρισται), δῆλον
389 b ὅτι πάντα τὰ σώματα ὅσα ἑκατέρου ἁπλῶς τοῦ
στοιχείου, ψυχρὰ μᾶλλόν ἐστιν, ἐὰν μὴ ἔχῃ ἀλλο-
τρίαν θερμότητα, οἷον τὸ ζέον ὕδωρ ἢ τὸ διὰ τέφρας
ἠθημένον· καὶ γὰρ τοῦτο ἔχει τὴν ἐκ τῆς τέφρας
θερμότητα· ἐν ἅπασι γάρ ἐστι θερμότης, ἢ πλείων
5 ἢ ἐλάττων, τοῖς πεπυρωμένοις· διὸ καὶ ἐν τοῖς
σαπροῖς ζῷα ἐγγίγνεται· ἔνεστι γὰρ θερμότης ἡ
φθείρασα τὴν ἑκάστου οἰκείαν θερμότητα.

Ὅσα δὲ κοινά, ἔχει θερμότητα· συνέστηκε γὰρ
τὰ πλεῖστα ὑπὸ θερμότητος πεψάσης. ἔνια δὲ

CHAPTER XI

ARGUMENT (*continued*)

be hot, though those that contain a predominance of water tend to be cold.

Note.—*Ch.* 11 *is complementary to ch.* 10; *ch.* 10 *deals with the proportions of dry and moist in homoeomerous bodies, ch.* 11 *with the proportions of hot and cold.*

WE must proceed to examine on the basis of what has been said which solids and which liquids are hot or cold. (1) Those composed of water are, generally speaking, cold, unless they have some external source of heat (as have lye, urine and wine); (2) those composed of earth are generally hot, having been manufactured by heat, like lime and ash.

It must be understood that cold is in a sense the material factor. For as dry and moist are matter (being passive), and find their principal embodiments in earth and water which have cold as a defining characteristic, it is clear that all bodies that are made of either element alone tend to be cold unless they have an external source of heat like boiling water or water strained through ash, which contains the heat from the ash; for everything that has been burned contains heat to a greater or lesser degree. The presence of heat is the reason why worms are generated in rotten material, the presence, that is, of the heat which has destroyed the material's own natural heat.[a]

(3) Things composed of more than one element contain heat, having most of them been formed by concoction by heat, though some are the products

Cf. 379 b 6, ch. 1, note *a* on p 296.

389 b

σήψεις εἰσίν, οἷον τὰ συντήγματα[1]· ὥστε ἔχοντα
μὲν τὴν φύσιν θερμὰ καὶ αἷμα καὶ γονὴ καὶ μυελὸς
καὶ ὀπὸς καὶ πάντα τὰ τοιαῦτα, φθειρόμενα δὲ καὶ
ἐξιστάμενα τῆς φύσεως οὐκέτι· λείπεται γὰρ ἡ
ὕλη, γῆ οὖσα ἢ ὕδωρ· διὸ ἀμφότερα δοκεῖ τισιν,
καὶ οἱ μὲν ψυχρὰ οἱ δὲ θερμὰ ταῦτά φασιν εἶναι,
ὁρῶντες, ὅταν μὲν ἐν τῇ φύσει ὦσιν, θερμά, ὅταν
δὲ χωρισθῶσιν, πηγνύμενα. ἔχει μὲν οὖν οὕτως,
ὅμως δέ, ὥσπερ διώρισται, ἐν οἷς μὲν ἡ ὕλη ὕδατος
τὸ πλεῖστον, ψυχρά (ἀντίκειται γὰρ μάλιστα τοῦτο
τῷ πυρί), ἐν οἷς δὲ γῆς ἢ ἀέρος, θερμότερα.

Συμβαίνει δέ ποτε ταὐτὰ γίγνεσθαι ψυχρότατα
καὶ θερμότατα ἀλλοτρίᾳ θερμότητι· ὅσα γὰρ μά-
λιστα πέπηγε καὶ στερεώτερά ἐστιν, ταῦτα ψυχρά
τε μάλιστα, ἐὰν στερηθῇ θερμότητος, καὶ κάει
μάλιστα, ἐὰν πυρωθῇ, οἷον ὕδωρ καπνοῦ καὶ ὁ λίθος
ὕδατος καίει μᾶλλον.

[1] συντήγματα 𝔚 𝔐 B_{rec} Ap : συντηκτά Fobes : cf. L&S[9], s.v.

[a] *Cf. De Gen. An.* I. 18, 724 b 21 ff.

CHAPTER XII

ARGUMENT

The next step is to deal in detail with the homoeomerous bodies, which we are now in a position to classify according to their material constituents, and which are in their turn the material of anhomoeomerous bodies (389 b 23-28) *In all cases the formal element is even more important than the material, though the more elementary the body the less obvious this is. Even the elements have their final cause, which is still more obvious in the parts of the body, each of which has*

of decay like the waste products [a] of the body. So as long as blood, semen, marrow, rennet and the like keep their proper nature they are warm, but once they perish and lose their proper nature they lose their warmth, for all that is left is their material factors, earth and water. So there are two views about them, and some regard them as cold, some as hot, seeing that as long as they retain their nature they are hot, but when they depart from it they solidify.[b] This is true. Nevertheless, as we have laid down, things in which the material factor is mainly water are cold (for water is the extreme opposite of fire), things in which it is mainly earth or air contain more heat.

It sometimes happens that bodies which are excessively cold become excessively hot under the influence of external heat—for the most solid and rigid bodies are also the coldest if deprived of heat, but they give the most heat after exposure to fire : thus water gives more heat than smoke and stone than water.

[b] *Cf.* 389 a 20-21.

CHAPTER XII

ARGUMENT (*continued*)

its specific function. So we may lay it down in general that things are what they are because of their ability to perform some function. And though heat and cold and their effects may be sufficient to account for the production of homoeomerous substances, it is clear that they are not sufficient to account for bodies made from those substances ; for in their production human craftsmanship or nature is also a factor (389 b 28—390 b 14). *In dealing with the homoeomerous*

bodies we should therefore, if possible, look for formal, material and efficient causes. We can then proceed to an-

389 b 23 Ἐπεὶ δὲ περὶ τούτων διώρισται, καθ' ἕκαστον λέγωμεν τί σὰρξ ἢ ὀστοῦν ἢ τῶν ἄλλων τῶν ὁμοιο-
25 μερῶν· ἔχομεν γὰρ ἐξ ὧν ἡ τῶν ὁμοιομερῶν φύσις συνέστηκεν, τὰ γένη αὐτῶν, τίνος ἕκαστον γένους, διὰ τῆς γενέσεως· ἐκ μὲν γὰρ τῶν στοιχείων τὰ ὁμοιομερῆ, ἐκ δὲ τούτων ὡς ὕλης τὰ ὅλα ἔργα τῆς φύσεως.

Ἔστιν δ' ἅπαντα ὡς μὲν ἐξ ὕλης ἐκ τῶν εἰρη-μένων, ὡς δὲ κατ' οὐσίαν τῷ λόγῳ. ἀεὶ δὲ μᾶλλον
30 δῆλον ἐπὶ τῶν ὑστέρων καὶ ὅλως ὅσα οἷον ὄργανα καὶ ἕνεκά του. μᾶλλον γὰρ δῆλον ὅτι ὁ νεκρὸς ἄνθρωπος ὁμωνύμως. οὕτω τοίνυν καὶ χεὶρ τελευ-
390 a τήσαντος ὁμωνύμως, καθάπερ καὶ αὐλοὶ λίθινοι λεχθείησαν ⟨ἄν⟩[1]· οἷον γὰρ καὶ ταῦτα ὄργανα ἅττα ἔοικεν εἶναι. ἧττον δ' ἐπὶ σαρκὸς καὶ ὀστοῦ τὰ τοιαῦτα δῆλα. ἔτι δ' ἐπὶ πυρὸς καὶ ὕδατος ἧττον·
5 τὸ γὰρ οὗ ἕνεκα ἥκιστα ἐνταῦθα δῆλον, ὅπου δὴ πλεῖστον τῆς ὕλης· ὥσπερ γὰρ εἰ καὶ τὰ ἔσχατα ληφθείη, ἡ μὲν ὕλη οὐδὲν ἄλλο παρ' αὐτήν, ἡ δ' οὐσία οὐδὲν ἄλλο ἢ λόγος, τὰ δὲ μεταξὺ ἀνάλογον τῷ ἐγγὺς εἶναι ἕκαστον, ἐπεὶ καὶ τούτων ὁτιοῦν ἐστιν ἕνεκά του, καὶ οὐ πάντως ἔχον ὕδωρ ἢ πῦρ,
10 ὥσπερ οὐδὲ σὰρξ οὐδὲ σπλάγχνον. τούτων δ' ἔτι μᾶλλον πρόσωπον καὶ χείρ. ἅπαντα δ' ἐστὶν ὡρι-σμένα τῷ ἔργῳ· τὰ μὲν γὰρ δυνάμενα ποιεῖν τὸ αὐ-τῶν ἔργον ἀληθῶς ἐστιν ἕκαστον, οἷον ὀφθαλμὸς

[1] ἄν suppl. Thurot O.T.

homoeomerous bodies and, finally, to things made up of them (390 b 14-22).

HAVING dealt with these matters, let us proceed to give separate accounts of flesh and bone and the other homoeomerous bodies. We can tell from their generation what is the constitution of the homoeomerous bodies, what are the classes into which they fall and to which class each belongs; for the homoeomerous bodies are composed of the elements, and serve in turn as material for all the works of nature.

But while the material of all the homoeomerous bodies is the elements we have mentioned, their essential reality is comprised in their formal definition. This is always clearer in the higher products of nature and, generally speaking, in things which are instrumental and serve a particular end. Thus it is only too clear that a corpse is a man in name only So also the hand of a dead man is a hand in name only, just as a sculptured flute might still be called a flute, for it also is an instrument of a kind. The distinction is less clear in the case of flesh and bone, and less clear again in the case of fire and water. For the final cause is least obvious where matter predominates. For just as, to take the two extremes, matter is simply matter, essential reality is simply formal definition, so things intermediate are related to these two extremes according to their proximity to each; for each of them has some final cause, and is not just water or fire, nor just flesh and intestines. And the same is even truer of face and hand. All these things, in fact, are determined by their function, and the true being of each consists in its ability to perform its particular function, of the eye, for instance, in its ability

390 a εἰ ὁρᾷ, τὸ δὲ μὴ δυνάμενον ὁμωνύμως, οἷον ὁ τεθνεὼς ἢ ὁ λίθινος· οὐδὲ γὰρ πρίων ὁ ξύλινος, ἀλλ' ἢ ὡς εἰκών. οὕτω τοίνυν καὶ σάρξ· ἀλλὰ
15 τὸ ἔργον αὐτῆς ἧττον δῆλον ἢ τὸ τῆς γλώττης. ὁμοίως δὲ καὶ πῦρ· ἀλλ' ἔτι ἧττον ἴσως δῆλον φυσικῶς ἢ τὸ τῆς σαρκὸς ἔργον. ὁμοίως δὲ καὶ τὰ ἐν τοῖς φυτοῖς καὶ τὰ ἄψυχα, οἷον χαλκὸς καὶ ἄργυρος· πάντα γὰρ δυνάμει τινί ἐστιν ἢ τοῦ ποιεῖν ἢ τοῦ πάσχειν, ὥσπερ σὰρξ καὶ νεῦρον· ἀλλ' οἱ
20 λόγοι αὐτῶν οὐκ ἀκριβεῖς. ὥστε πότε ὑπάρχει καὶ πότε οὔ, οὐ ῥᾴδιον διιδεῖν, ἂν μὴ σφόδρα ἐξίτηλον ᾖ καὶ τὰ σχήματα μόνα ᾖ λοιπά, οἷον καὶ τὰ τῶν παλαιουμένων νεκρῶν σώματα ἐξαίφνης τέφρα γίγνεται ἐν ταῖς θήκαις· καὶ καρποὶ μόνον τῷ σχή-
390 b ματι, τῇ δ' αἰσθήσει[1] οὐ φαίνονται, παλαιούμενοι σφόδρα· καὶ τὰ ἐκ τοῦ γάλακτος πηγνύμενα.

Τὰ μὲν οὖν τοιαῦτα μόρια θερμότητι καὶ ψυχρότητι καὶ ταῖς ὑπὸ τούτων κινήσεσιν ἐνδέχεται γίγνεσθαι, πηγνύμενα τῷ θερμῷ καὶ τῷ ψυχρῷ·
5 λέγω δ' ὅσα ὁμοιομερῆ, οἷον σάρκα, ὀστοῦν, τρίχας, νεῦρον, καὶ ὅσα τοιαῦτα· πάντα γὰρ διαφέρει ταῖς πρότερον εἰρημέναις διαφοραῖς, τάσει, ἕλξει, θραύσει, σκληρότητι, μαλακότητι καὶ τοῖς ἄλλοις τοῖς τοιούτοις· ταῦτα δὲ ὑπὸ θερμοῦ καὶ ψυχροῦ καὶ τῶν
10 κινήσεων γίγνεται μειγνυμένων. τὰ δ' ἐκ τούτων συνεστῶτα οὐδενὶ ἂν ἔτι δόξειεν τὰ ἀνομοιομερῆ, οἷον κεφαλὴ ἢ χεὶρ ἢ πούς, ἀλλ' ὥσπερ καὶ τοῦ χαλκὸν μὲν ἢ ἄργυρον γενέσθαι αἰτία ψυχρότης καὶ

[1] τῇ δ' αἰσθήσει Ⅿt Ⅿ: κατὰ τὴν δ' αἴσθησιν ci. Thurot: τὴν δ' αἴσθησιν Fobes.

to see; while if it cannot perform its function it is that thing in name only, like a dead man or a stone figure of a man. Nor is a wooden saw, properly speaking, a saw but merely a representation of one. This is all equally true of flesh, but its function is less obvious than that of, *e g* , the tongue ; it is true of fire, but its natural function is even less obvious than that of flesh. It is equally true of plants and inorganic bodies like bronze and silver, for they are all what they are because of their ability to perform some active or passive function, like flesh and sinew, but their precise formal definitions are not apparent, and so it is difficult to perceive when they are operative and when they are not, unless the particular body is very decayed and retains few of its properties but its outward appearance. For example, ancient corpses sometimes suddenly turn to dust in their tombs, and some fruits when they get very old retain only their appearance and not their other sensible qualities, as do also solids formed from milk.

Heat and cold and the motions set up by them are therefore, since solidification is due to heat and cold, sufficient to produce all parts of this sort,[a] that is to say, all homoeomerous parts like flesh, bone, hair, sinew and the like : for these are all distinguished by the differentia we have already described (tension, ductility, fragmentability, hardness, softness and the rest) which are produced by heat and cold and the combination of their motions. But no one would suppose that this was the case with the anhomoeomerous bodies which they in turn compose (for example, head, hand or foot), for though cold and heat and their motion will account for the production

[a] *Cf.* Introduction, pp. xv-xvi.

390 b θερμότης καὶ κίνησις, τοῦ δὲ πρίονα ἢ φιάλην ἢ κιβωτὸν οὐκέτι, ἀλλ' ἐνταῦθα μὲν τέχνη, ἐκεῖ δὲ φύσις ἢ ἄλλη τις αἰτία

15 Εἰ οὖν ἔχομεν τίνος γένους ἕκαστον τῶν ὁμοιομερῶν, ληπτέον καθ' ἕκαστον τί ἐστιν, οἷον τί αἷμα ἢ σὰρξ ἢ σπέρμα καὶ τῶν ἄλλων ἕκαστον· οὕτω γὰρ ἴσμεν ἕκαστον διὰ τί καὶ τί ἐστιν, ἐὰν ἢ τὴν ὕλην ἢ τὸν λόγον ἔχωμεν, μάλιστα δ' ὅταν ἄμφω τῆς τε γενέσεως καὶ φθορᾶς, καὶ πόθεν ἡ ἀρχὴ τῆς

20 κινήσεως. δηλωθέντων δὲ τούτων ὁμοίως τὰ ἀνομοιομερῆ θεωρητέον, καὶ τέλος τὰ ἐκ τούτων συνεστῶτα, οἷον ἄνθρωπον, φυτόν, καὶ τἆλλα τὰ τοιαῦτα.

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[a] *Cf. De Gen. et Corr.* II. 9, *De Part. An.* II. 1.

of bronze or silver, they will not account for the production of a saw or a cup or a box. Here human craftsmanship is the cause, while in other cases it is nature or some other cause.

Knowing, therefore, into which class each of the homoeomerous bodies fall, we should proceed to describe each of them, giving the definition of blood, flesh, semen and all the rest. For we know the cause and nature of a thing when we understand either the material or formal factor in its generation and destruction, or best of all if we know both, and also its efficient cause. When we have thus explained the homoeomerous bodies we must similarly examine the anhomoeomerous, and finally the bodies composed from them, such as men, plants and the like.[a]

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